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SOME AUSTRALIAN POLYCLADS

(*Turbellaria*)

By Libbie H. Hyman

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(Figures 1–21)

(Manuscript received 4.7.58)

The material of this article was kindly furnished by Miss Elizabeth Pope, Curator of Worms and Echinoderms, the Australian Museum, Sydney, who was assisted in collecting by Misses P. McDonald, F. Wilson and B. Dew, and by Mr. Ederic Slater, who also took a series of kodachromes, which have been of great aid in establishing the colour in nature. Miss Pope also sent valuable notes and colour sketches.

All the specimens were collected in the intertidal zone at Long Reef, near Collaroy, north of Sydney, New South Wales, during the summers of 1955 and 1956. The material comprised 30 specimens, belonging to 10 species, of which three are identical with species in Haswell's (1907) report; the remainder are considered new.

Extensive definitions of families and genera appear in my 1953 monograph but are repeated here for the benefit of Australian zoologists. Unfortunately, acotylean polyclads cannot be identified except by means of serial sections of the copulatory apparatus. Cotylean polyclads may often be identified by the colour pattern. The eye arrangement can be made out accurately only in dehydrated, cleared specimens. Field identification is generally impossible except in the case of species with striking colour patterns.

Order Polycladida

Suborder Acotylea

Polyclads without a sucker behind the female gonopore; eyes never in a pair of clusters on the anterior margin; tentacles when present of the nuchal type; copulatory complex usually in the posterior body half.

SECTION CRASPEDOMMATA

Acotylea with eyes in a band along the whole or the anterior part of the body margin; eyes usually also present elsewhere; rarely completely devoid of eyes; pharynx ruffled; copulatory apparatus in the posterior body half behind the pharynx, with male apparatus directed backward and uteri extending forward.

Family **Discocelidae** Laidlaw, 1903

Craspedommata with eyes, apart from the marginal band, limited to definite cerebral and tentacular clusters; tentacles wanting or rudimentary; penis massive, muscular, lobulated, depending vertically from the dorsal wall of the male antrum; penis edged with numerous small prostatic apparatuses, which may also be present in the antral wall; Lang's vesicle present, usually crescentic.

Genus **Discocelis** Ehrenberg, 1832

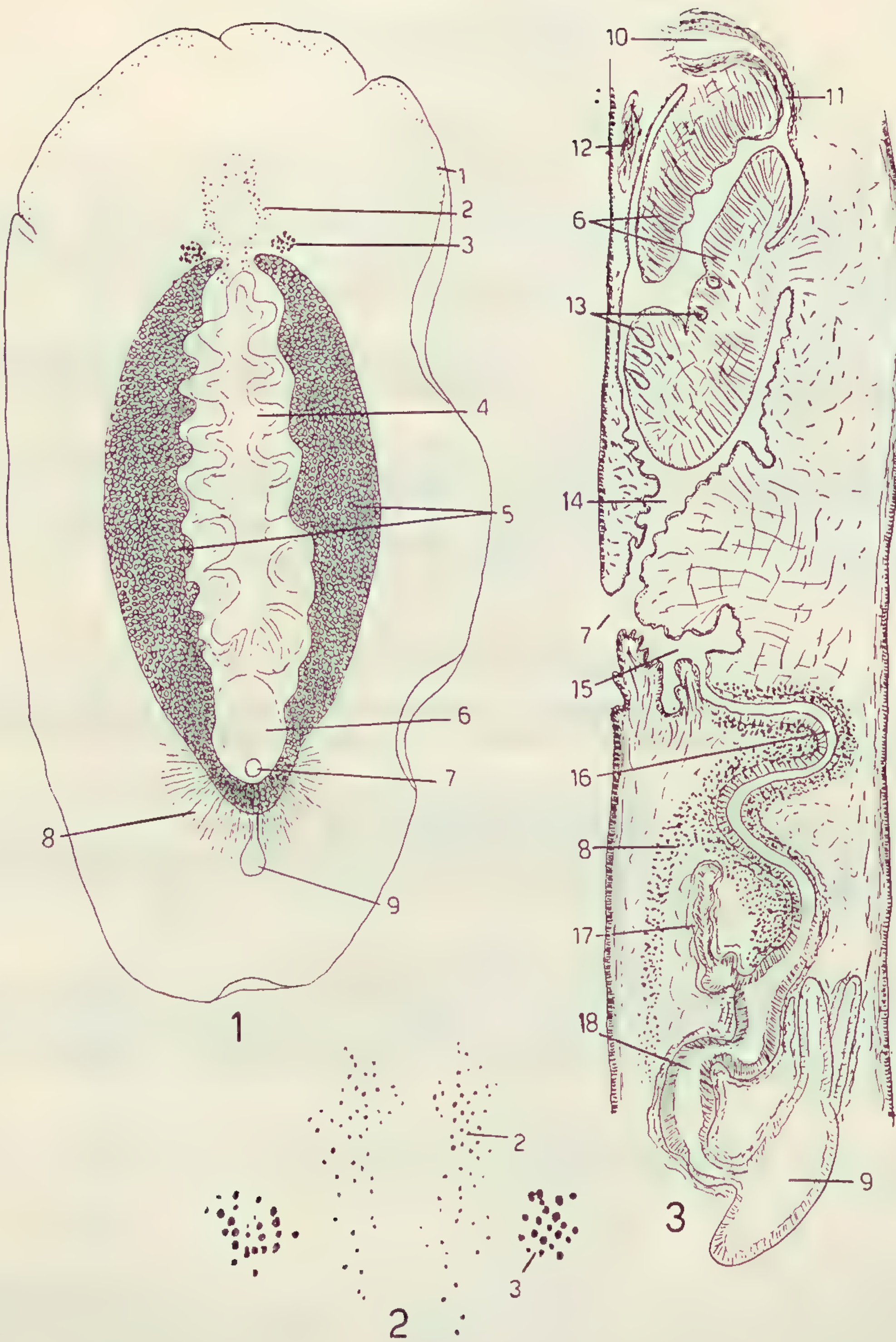
Discocelidae without prostatic vesicle or without antral pockets occupied by a large prostatoid.

Discocelis australis, sp. nov.

(Figures 1-4)

This is evidently one of the common species of the area as the collection contains five specimens. The form is broadly oval (Fig. 1), anteriorly rounded, tapering somewhat posteriorly to an obtuse end. The largest specimen preserved is 31 mm long by 13 mm across the middle but the fully extended worm is no doubt considerably longer. The colour is given in notes, colour sketches and kodachromes as fawn, dotted with dark brown spots, more concentrated medially. This is a common colour pattern in the genus, hence is not distinctive. Figure 4 is an attempt to represent the form and appearance from a kodachrome.

The eye arrangement is shown in Figure 1 from a cleared specimen. There is a pair of tentacular clusters, evident in life, of about 25 eyes each. The cerebral clusters are elongated groups, beginning thinly behind the level of the tentacular clusters and widening as they extend forward between the latter. The pattern of the cerebral and tentacular clusters is given in Figure 2, drawn with the aid of a camera lucida. The band of marginal eyes extends to about the level of the brain.



Figs. 1 to 3.—*Discocelis Australis*. 1. Cleared whole specimen, showing general structure. 2. Eyes, enlarged. 3. Sagittal view of copulatory complex, anterior end above.

Key for anatomy: 1. marginal eyes; 2. cerebral eyes; 3. tentacular eyes; 4. pharynx; 5. uteri filled with eggs; 6. penis; 7. common gonopore; 8. cement glands; 9. Lang's vesicle; 10. seminal vesicle; 11. ejaculatory duct; 12. spermiducal vesicle; 13. prostatoids; 14. male antrum; 15. female antrum; 16. vagina; 17. common stem of uteri; 18. duct of Lang's vesicle.

In the cleared worm (Fig. 1) is seen the elongated ruffled pharynx, also evident in some of the kodachromes, bounded laterally by the broad uteri stuffed with eggs. The uteri are not confluent anteriorly but terminate to the medial side of the tentacular eye clusters. Behind the pharynx a mass indicates the penis; behind this is seen the common gonopore with radiating cement glands. The flask-shaped median part of Lang's vesicle terminates the female copulatory apparatus.

A median sagittal view of the copulatory apparatuses is given in Figure 3. The sperm ducts ascending from below enter separately a small but muscular seminal vesicle from which the ejaculatory duct continues, curving backward to enter the penis. This is not the usual conical projection but as typical of the genus a massive lobulate body depending from above into the male antrum. It here consists of two main lobes which are edged with little pyriform prostatic apparatuses. Very few of these appear in the median section and they are rather scanty altogether in this species where they are also wanting from the wall of the male antrum. Behind the penis the male antrum extends inward to demarcate the posterior lobe of the penis and here is lined with a glandular epithelium. Behind the penis, the male antrum exits by a slanting passage to the common gonopore.

From the common gonopore a chamber that may be considered the female antrum ascends with a slight backward slant and receives the vagina. This takes a long sinuous horizontal course, receiving numerous cement glands and having a good muscular provision. Its lining epithelium is much taller ventrally than dorsally, no doubt because the cement glands enter the ventral wall. The cement glands cease at the entrance of the common stem of the uteri and at this place the vagina widens and becomes continuous with the canal of Lang's vesicle. This canal is also sinuous with a broad lumen lined by a tall epithelium underlain by circular and longitudinal muscle fibres. The canal finally narrows and enters the main sac of Lang's vesicle, which has the usual crescentic shape typical of the genus with two anterior prolongations.

Of the seven previously described species of *Discocelis*, two have separate male and female gonopores. Of the other five, four lack a seminal vesicle and the fifth, *D. lichenoides* (Mertens, 1832), which actually is the type species of the genus, is so poorly known that comparisons are impossible. The original description gives its colour as yellowish-brown with dark streaks.

Holotype: One specimen, anterior half as whole mount, posterior half as sagittal serial sections (7 slides) deposited in the Australian Museum. [Reg. No. W.3684.]

Family **Stylochidae** Stimpson, 1857

Craspedommata of oval form and usually thick consistency; with or without tentacles; with tentacular and cerebral eye clusters, also often with frontal eyes; with or without true seminal vesicle and spermiducal bulbs; prostatic vesicle free.

Genus **Leptostylochus** Bock, 1925

Stylochidae of oval to elongate form and thin to moderate consistency; marginal eyes limited to anterior body half; tentacles small or wanting; pharynx elongated with mouth posterior to the middle; gonopores separate; with no or slightly developed seminal vesicle; with spermiducal bulbs; glandular vagina widened; with well-developed Lang's vesicle.

Leptostylochus novacambrensis, sp. nov.

(Figures 5-6)

This species also appears common in the locality as the collection contains nine specimens. The worm is of broadly oval form and somewhat thin consistency. It is rather small, measuring 15 by 11 mm in the largest specimen in the material. The colour as shown by a colour sketch and a kodachrome is brown, mottled or dotted with dark brown. Small tentacles are present as shown in Figure 5.

The marginal eyes form a somewhat wide band around nearly the anterior half of the body margin (Fig. 5). The small tentacles each contain a few eyes. The definitely paired cerebral groups begin slightly behind the brain and expand laterally as they extend forward but do not quite reach the marginal band. The cerebral eyes are fewer in number than in other species of the genus.

The pharynx is elongated with short lateral folds as usual in the genus (Fig. 5); the mouth is somewhat posteriorly located with reference to the pharynx. Laterally the pharynx is bounded on each side by the coils of the uteri filled with eggs. The uteri are confluent at the anterior end of the pharynx just behind the brain. Behind the pharynx is seen the vagina surrounded by radiating cement glands and behind these the sac of Lang's vesicle.

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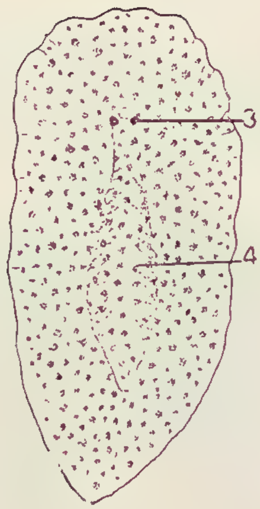

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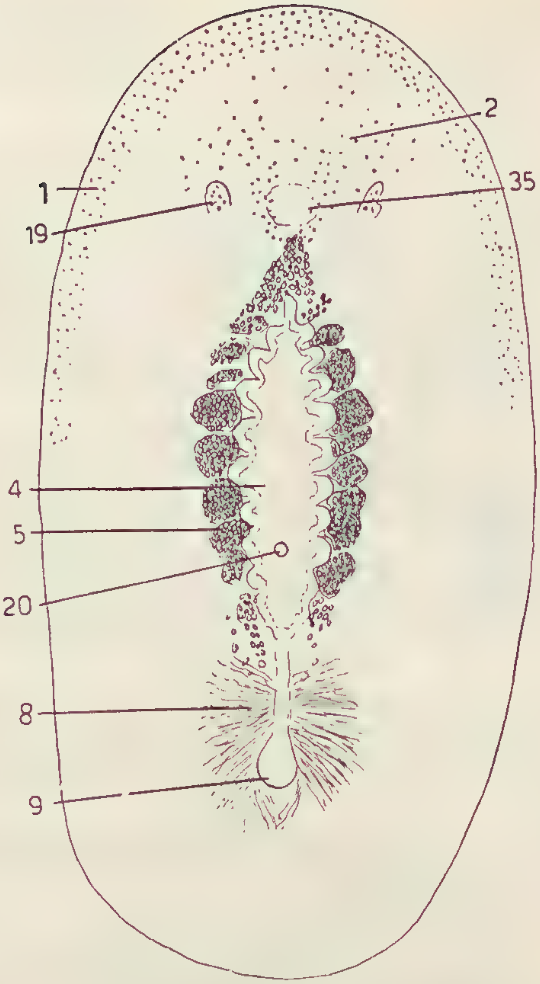

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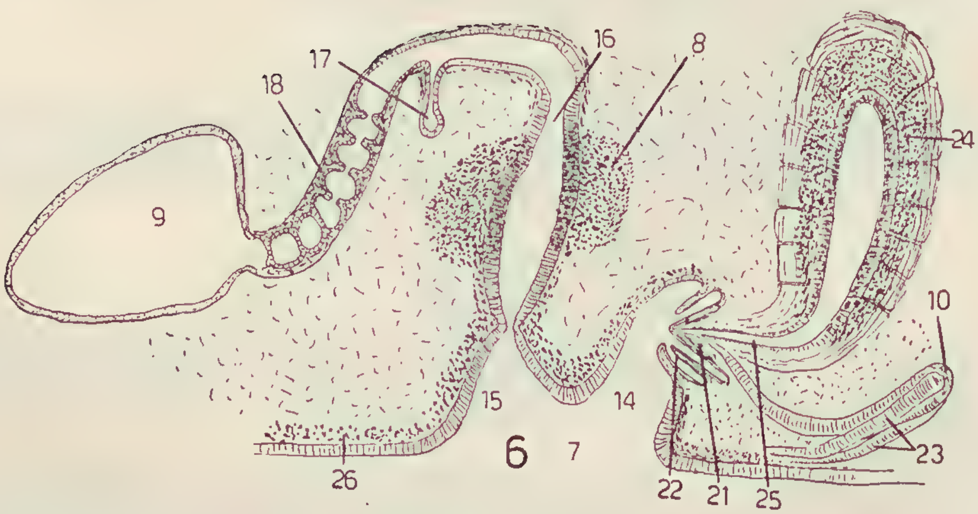


Fig. 4.—*Discocelis australis*, sketch from kodachrome, showing appearance in life.

Figs. 5 to 6.—*Leptostylochus novacambrensis*. 5. Cleared whole specimen, showing general structure. 6. Sagittal view of the copulatory complex, anterior end to right.

Key for anatomy: 1. marginal eyes; 2. cerebral eyes; 3. tentacular eyes; 4. pharynx; 5. uteri filled with eggs; 7. common gonopore; 8. cement glands; 9. Lang's vesicle; 10. seminal vesicle; 14. male antrum; 15. female antrum; 16. vagina; 17. common stem of uteri; 18. duct of Lang's vesicle; 19. tentacles; 20. mouth; 21. penis papilla; 22. penis sheath; 23. spermiducal bulbs; 24. prostatic vesicle; 25. prostatic duct; 26. muscle layer; 35. brain.

The copulatory region was removed from two specimens and sectioned sagittally. The ovaries occur in a dorsal position but testes were not in evidence in the pieces sectioned. A sagittal view of the copulatory apparatuses is given in Figure 6. The male apparatus, situated immediately behind the pharynx, is of the stylochid type. The terminal parts of the sperm ducts, approaching the apparatus from behind near the ventral wall, are muscularized, having a coat of circular fibres, hence they constitute what I have termed spermiducal bulbs. They enter separately the proximal end of the ejaculatory duct, here slightly enlarged as a seminal vesicle, also with a strong coat of circular muscle fibres. This proceeds posteriorly as an ejaculatory duct of steadily decreasing diameter and finally joins the prostatic duct inside the penis papilla. The prostatic vesicle is a relatively large oval body with a thick muscular wall of fibres paralleling its external contour, and a glandular lining epithelium. In one of the sectioned series, the prostatic vesicle has a vertical orientation as in Figure 6, but in the other series is almost horizontal in position. The glandular epithelial lining, permeated with eosinophilous granules, is not thrown into folds, as reported for the other species of the genus. The glands that provide the eosinophilous secretion appear located in the muscular wall. They could not be detected outside the vesicle. However, in one of the sectioned specimens the typical passages through the prostatic wall are present and have been added to Figure 6, although apparently not present in the series from which this drawing was made. These passages carry the ducts of the extraprostatic glands but could not be traced to glands and in fact seemed to consist of muscle fibres. Extraprostatic glands are usual in the genus. Distally the lumen of the prostatic vesicle narrows to become the prostatic duct that passes along the centre of the conical penis papilla within which it is joined by the ejaculatory duct. The penis papilla, fairly muscular, is provided with a penis sheath, that is, a fold of the male antrum; this is very evident in one series, less so in the other. A penis sheath is not usual in the genus, being reported only for *L. capensis* Palombi, 1938, where its form is peculiar. The penis papilla projects into the anterior side near the inner end of the vertically oriented male antrum. This has the shape of a funnel and is lined distally with a high epithelium at the male gonopore.

The female gonopore lies not far behind the male pore and as the intervening body wall is short, not reaching the level of the general body wall, the two pores could almost be said to open in common. From the female gonopore the female antrum, also of funnel shape and lined by an epithelium of tall, slender cells underlain by a strong musculature, ascends, gradually narrowing to the beginning of the glandular vagina. This very narrowed beginning of the vagina is reported as encircled by a sphincter muscle in the type species, *L. elongatus*, but this is wanting here. The vagina immediately widens into a broad tube lined by an epithelium of tall narrow cells underlain by a strong musculature and permeated by the eosinophilous secretion of the cement glands. The glandular vagina ascends vertically, then narrowing abruptly and ceasing to receive cement glands, turns posteriorly and after a short horizontal course receives from below the common stem of the uteri. It then continues as the duct of Lang's vesicle which curves ventrally and enters the sac of Lang's vesicle, of moderate size. The epithelium of the duct of Lang's vesicle is thrown into a succession of scallops supported by muscle fibres. This condition is also seen in other species of the genus. The sac of the vesicle is devoid of musculature.

Of the five previously described species of the genus, one, *L. ovatus* Kato, 1937, is very atypical of the genus and family in that the ejaculatory duct enters the proximal part of the prostatic vesicle. The present species differs from all the others in having definite, if small, tentacles. Its Lang's vesicle is only about half the size of that of *L. elongatus* Bock, 1925, *L. gracilis* Kato, 1934, and *L. capensis* Palombi, 1938. *Leptostylochus polysorus* (Schmarda, 1859), reinvestigated by Stummer-Traunfels (1933), has a Lang's vesicle of moderate size but its penis papilla is long and slender, its spermiducal bulbs are small and globular, and a constriction is lacking at the beginning of the glandular vagina. The present species also differs from all the others in the lack of a scalloped lining of the prostatic vesicle.

Holotype: Anterior half as whole mount, copulatory region as serial sections (4 slides), deposited in the Australian Museum. [Reg. No. W.3686.]

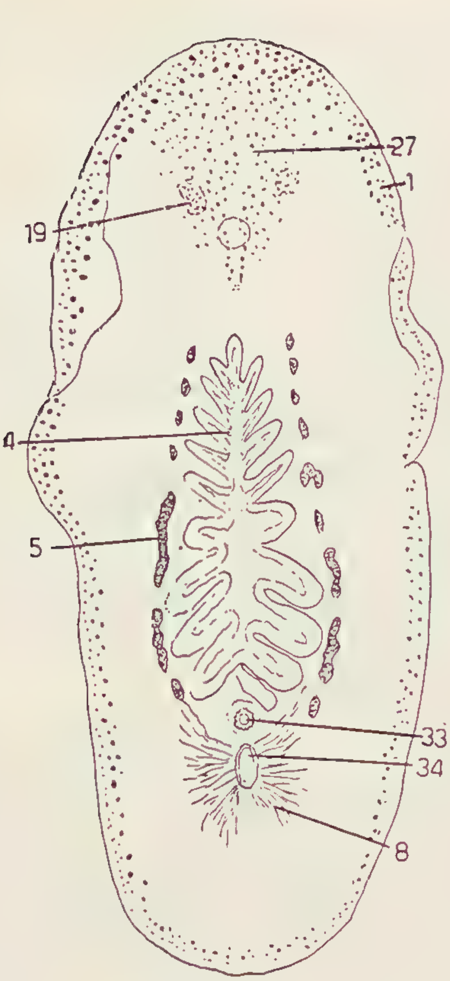
Genus **Enterogonia** Haswell, 1907

Stylochidae with rudimentary tentacles; marginal eyes completely encircling the margin; with cerebrofrontal eyes; with or without very small free prostatic vesicle; seminal vesicle wanting; vaginal duct entering the intestine.

Enterogonia pigrans Haswell, 1907

(Figures 7-8)

This is one of the more interesting species in Haswell's well known article of 1907 on Australasian polyclads. The collection contained four specimens of which some appeared juvenile. There is also a colour sketch and three kodachromes.



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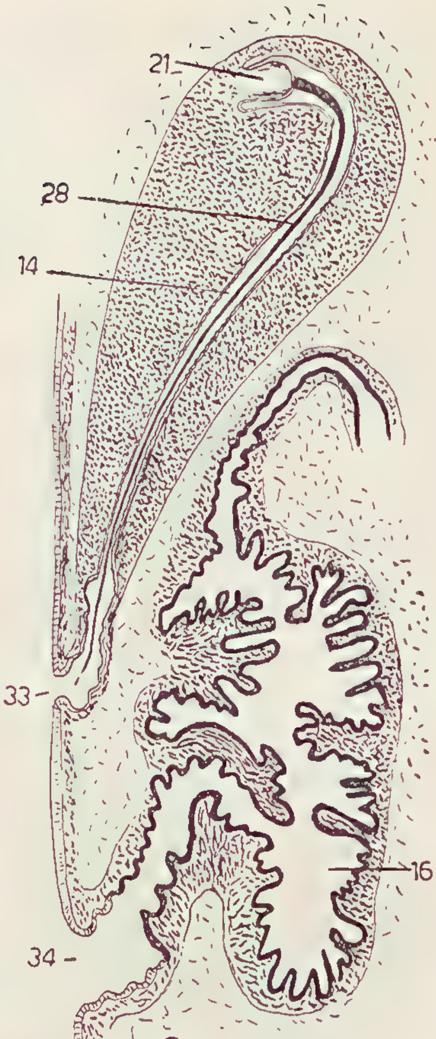

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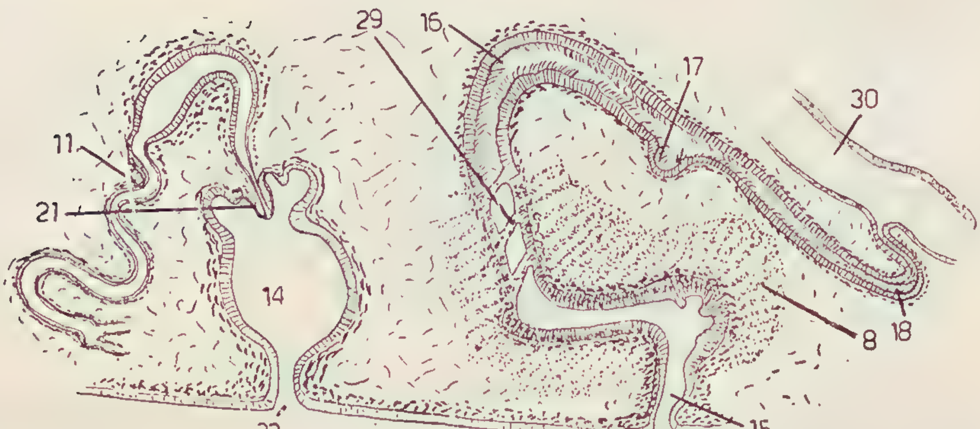

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Figs. 7 to 8.—*Enterogonia pigrans*. 7. Cleared whole specimen, showing general features. 8. Sagittal view of copulatory complex, anterior end to left.

Fig. 9.—*Notoplana australis*, distal parts of copulatory complex, anterior end above.

Key for anatomy: 1. marginal eyes; 4. pharynx; 5. uteri filled with eggs; 8. cement glands; 11. ejaculatory duct; 14. male antrum; 15. female antrum; 16. vagina; 17. common stem of uteri; 18. duct of Lang's vesicle; 19. tentacles; 21. penis papilla; 27. cerebrofrontal eyes; 28. penis stylet; 29. spiral ridge; 30. intestine; 33. male gonopore; 34. female gonopore.

This is a small worm of oval form (Fig. 7); the largest measured 15 mm in length by about 6 mm in width. Reports of the colour are discrepant. The three kodachromes show the ground colour as light brown dotted with darker brown. Haswell gave the colour as greenish or grey, seen under magnification to be composed of dots. Miss Pope's colour sketch is greenish-brown and her description gives the colour as pale olive green or a light brown ground.

The band of marginal eyes completely encircles the margin. It is rather wide in larger specimens but narrower and indistinct posteriorly in smaller ones. It is characteristic of the marginal eyes that the inner members of the band are larger than the more peripheral ones. The centre of the anterior end bears numerous small eyes that form a fan-shaped cerebrofrontal group. This begins narrowly behind the brain and expands anteriorly, merging into the marginal band. There appears to be present a pair of rudimentary tentacles as a white slightly elevated area on each side containing more concentrated eyes than the rest of the cerebrofrontal group. These tentacular elevations are very difficult to see in cleared specimens but seem to be more evident in life as a pair of spots. They are not mentioned by Haswell.

The postpharyngeal region of the largest specimen was removed and sectioned sagittally. The contained copulatory apparatuses (Fig. 8) were found in agreement with Haswell's description and figure. The male system is positively devoid of any indication of a prostatic vesicle and also lacks a seminal vesicle. The male gonopore leads into a rather roomy muscular male antrum into whose upper end projects the small rounded penis papilla. This appears smaller than in Haswell's figure and the slight fold at its base, which seems to be an incipient penis sheath, is also lacking from Haswell's figure. From the penis papilla the ejaculatory duct ascends and then curves backward, gradually widening. There is produced a curved chamber of some width provided with a layer of mainly circular muscle fibres outside the epithelium. From this chamber the ejaculatory duct, much narrowed but still with a muscular coat, descends in coils to a point near the ventral wall where it receives the sinuous spermiducal vesicles.

The female gonopore lies well behind the male pore. From it the short narrow female antrum ascends and soon widens into the glandular vagina lined by a columnar epithelium and receiving the numerous cement glands. The vagina soon curves posteriorly, continues horizontally for some distance, then ascends with an anterior slant. This slanted ascending portion contains the spiral ridge mentioned by Haswell. At the level of the dorsal end of this spiral ridge the cement glands cease. The vagina now curves posteriorly, being lined by a columnar ciliated epithelium underlain by circular musculature and after receiving from below the common stem of the uteri continues posteriorly as a vaginal duct. This is also ciliated and provided with a muscular coat. It proceeds posteriorly parallel to and just beneath the main intestine which it enters by a short upward curve.

In 1925, Bock described some specimens from New Zealand as *Enterogonia pigrans novae-zealandiae*. These differ from the Australian specimens in their larger size (to 34 mm), less roomy male antrum, larger penis papilla, lack of expansion at the beginning of the vagina, and above all by the presence of a small free prostatic vesicle springing from the enlarged chamber of the ejaculatory duct, just before the latter descends in coils. In 1933, Stummer-Traunfels, reinvestigating the material of Schmarda (1859), found that Schmarda's species *Polycelis orbicularis*, also from New Zealand, is identical with *Enterogonia pigrans novae-zealandiae*. If the New Zealand form is regarded as specifically distinct from the Australian form, a view that could be justified by the differences mentioned above, then Bock's name becomes *Enterogonia orbicularis* (Schmarda). If the two forms are considered of only subspecific value it would become necessary to call Bock's subspecies *Enterogonia orbicularis orbicularis* and Haswell's form *Enterogonia orbicularis pigrans*. It seems desirable to avoid this by regarding the two as distinct species.

Whole mounts and sections of *Enterogonia pigrans* have been deposited in the Australian Museum. [Reg. Nos. W.3688, W.3689.]

SECTION SCHEMATOMMATA

Acotylea without marginal eyes; eyes usually limited to paired tentacular and cerebral clusters but sometimes otherwise; with or without nuchal tentacles; pharynx ruffled or tubular; copulatory complexes behind the pharynx with uteri extending forward.

Family Leptoplanidae Stimpson, 1857

Schematommata of small to moderate size, with or without tentacles; pharynx ruffled; uteri usually confluent at the anterior end of the pharynx; usually with true seminal vesicle, sometimes wanting; usually without spermiducal bulbs; prostatic vesicle interpolated, absent in some genera; with or without penis stylet; with or without Lang's vesicle.

Genus Notoplana Laidlaw, 1903

Leptoplanidae generally without tentacles; with true seminal vesicle; prostatic vesicle always present, its interior subdivided into longitudinal chambers that surround the central ejaculatory duct which therefore projects well into its interior; usually with Lang's vesicle.

Notoplana australis (Schmarda, 1859)

(Figure 9)

Polycelis australis Schmarda, 1859.

Leptoplana australis Laidlaw, 1904.

Leptoplana australis, Haswell, 1907.

Notoplana australis, Bock, 1913.

The collection contains two specimens of this species, stated by Haswell to be the commonest and largest Australian polyclad, reaching a length of 75 mm. The larger of the two specimens was 25 mm long, 9-10 mm wide. The colour was described as olive grey; the accompanying colour sketch is greenish-grey. Haswell described the larger specimens as very dark, some almost black, whereas the smaller specimens are a light general shade of brown, often with olive-green intestinal branches. The coloured figure of Schmarda (1859) shows the colour of a 30 mm specimen as dark brown.

Stummer-Traunfels (1933), reinvestigating Schmarda's material, showed that his *Polycelis australis* is identical with Laidlaw's species. It appears that by accident both authors selected the same specific name.

My identification was based on serial sagittal sections of the posterior part of the larger worm. As several descriptions of this species exist in the literature, of which the most extensive is that of Haswell, I will refrain from a full description. I will remark that in my sections the convolutions of the vagina are far more complicated than in other published figures and that the muscular wall of the male antrum is far thicker than represented by Bock, resembling instead Haswell's figure. Hence, I present Figure 9. Further, the musculature of the antral wall courses mainly in a circular direction, not longitudinally as shown by Bock, also by Marcus (1954) for a variant *huina* from Chile. The stylet in the Australian specimen springs from a rounded penis papilla, not shown in other existing figures.

Specimens: Both specimens in alcohol have been returned to the Australian Museum; also the set of sagittal serial sections (4 slides) made from the posterior part of one of them. [Reg. No. W.3691.]

Notoplana longisaccata, sp. nov.

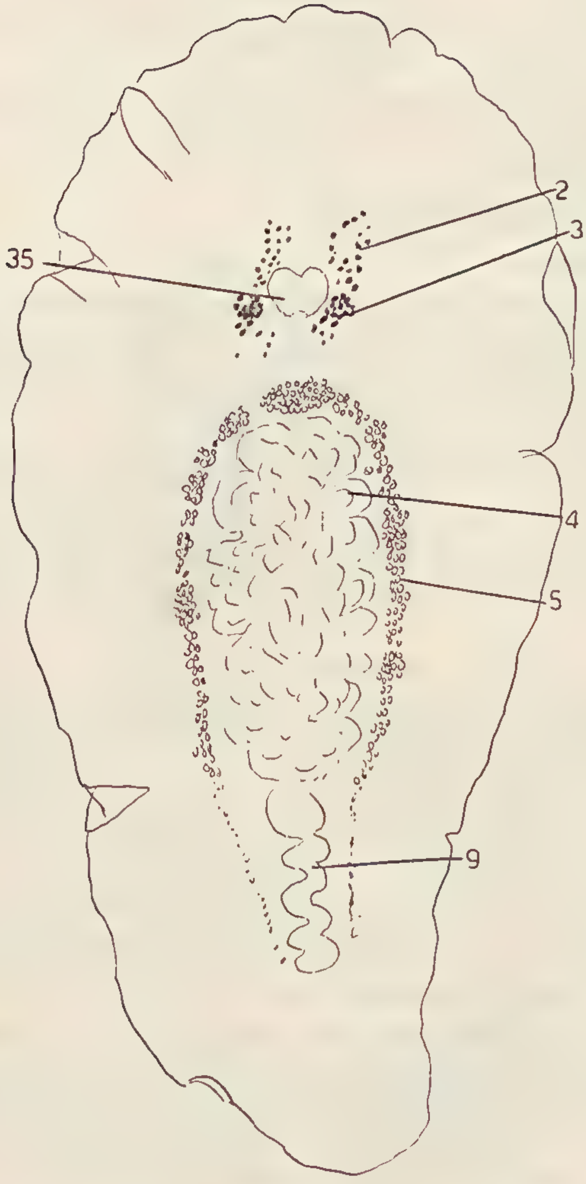
(Figures 10-11)

The single specimen (Fig. 10) is of obovate shape, 16 mm long by 8 mm in width at the widest part. The accompanying kodachrome (10c) shows a more slender, elongated shape. In life the animal is pale and transparent with the pharynx showing brown.

The cleared worm (Fig. 10) shows the eyes, the greatly ruffled pharynx, and the extremely long Lang's vesicle. The eyes occur in the usual cerebral and tentacular clusters. The latter form compact groups of about 8-10 eyes on each side. The smaller cerebral eyes occur in elongated groups, with a few eyes behind the tentacular clusters, most anterior to the latter.

The posterior part of the worm was removed and sectioned sagittally. The copulatory apparatuses are shown in sagittal view in Figure 11. They are notable for excessive muscularity. The fairly extensive male antrum ascends vertically, soon acquiring a thick coat of mostly circular muscles. Into its upper end projects the elongated, only slightly muscular penis papilla. This is directly continuous with the oval prostatic vesicle, with the usual thick muscular wall and glandular epithelium. No extra-capsular prostatic glands were in evidence. As typical of the genus the ejaculatory duct projects into the prostatic vesicle. Beneath the prostatic vesicle is the fusiform, muscular seminal vesicle leading to the proximal end of the prostatic vesicle by an arched ejaculatory duct.

The female gonopore lies not far behind the male pore but well separated from it. It leads into a short antrum which is narrowed at the entrance of the vagina. The vagina with very thick muscular wall, hence constituting a bulbous vagina, ascends vertically, then makes an anterior curve. The muscular wall diminishes greatly, beginning with this curve, but is still evident along the whole course of the vagina. The latter curves backwards, descends, and after receiving from below the common stem of the uteri continues as the short duct of Lang's vesicle. This has the scalloped epithelium often seen in this duct and soon enters the Lang's vesicle. The whole curve of the vagina to the entrance of the common uterus received cement



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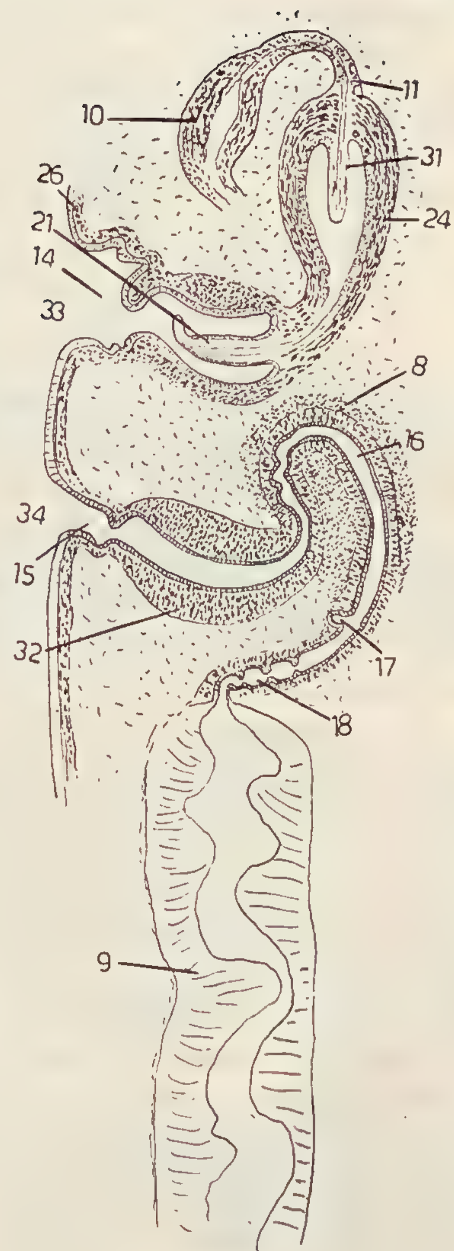

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Figs. 10 to 11.—*Notoplana longisaccata.* 10. Cleared whole specimen, showing general features. 11. Sagittal view of copulatory complex, anterior end above.

Key for anatomy: 2. cerebral eyes; 3. tentacular eyes; 4. pharynx; 5. uteri filled with eggs; 8. cement glands; 9. Lang's vesicle; 10. seminal vesicle; 11. ejaculatory duct; 14. male antrum; 15. female antrum; 16. vagina; 17. common stem of uteri; 18. duct of Lang's vesicle; 21. penis papilla; 24. prostatic vesicle; 26. muscle layer; 31. projection of ejaculatory duct into prostatic vesicle; 32. bulbous vagina; 33. male gonopore; 34. female gonopore; 35. brain.

glands throughout its wall. The Lang's vesicle is of extraordinary length. Because of limitations of space only half its length is shown in Figure 11. Actually it is about 2.6 mm long, about one-sixth the length of the (preserved) worm. The vesicle consists of a very high, granular epithelium covered with a thin fibrous coat.

Among the many species of *Notoplana*, the present species differs from all others in the remarkable length of Lang's vesicle. Other differentiating characters are the bulbous vagina, unusual in the genus, the muscular male antrum, and the elongated slender penis papilla.

Holotype: Anterior part as whole mount, copulatory region as sagittal serial sections (3 slides) deposited in the Australian Museum. [Reg. No. W.3692.]

Notoplana longiducta, sp. nov.

(Figures 12-13)

The collection contains two specimens of this species. It is of long and slender form (Fig. 12); the specimens are 19 and 15 mm long, respectively, and 3-4 mm wide. The kodachrome (6c) however, shows the anterior end as more expanded than in the preserved specimens. The colour is given as a transparent brown to olive green. The species is stated by Miss Pope to be extremely common on the coast of New South Wales.

The cleared whole worm (Fig. 12) shows the eyes, the pharynx embraced by the coils of the uteri containing eggs, and the location of male and female gonopores. The pharynx is notable for its somewhat anterior position also shown on the kodachrome. Tentacular and cerebral eye clusters form a continuous group on each side, in which the tentacular eyes are distinguishable by their larger size. They are relatively few in number. The much smaller and more numerous cerebral eyes occur in part behind the tentacular clusters but most are located anterior to these.

The appropriate part of the larger specimen was removed and sectioned sagittally. A sagittal view of the copulatory complex is given in Figure 13. The male system was found in rather poor histological condition, and further was not cut exactly in the sagittal plane; hence its structure was made out with some difficulty but probably corresponds fairly well to Figure 14. The male antrum ascends and widens into a chamber that appeared more irregular in contour than as represented in the figure. It has a strong muscular wall and houses the fairly elongated pointed penis papilla. From its upper end the ejaculatory duct curves anteriorly and pursues a long sinuous course in the anterior direction, finally joining the oval prostatic vesicle. The latter is chambered in typical *Notoplana* fashion and is lined by a glandular epithelium underlain by the usual thick muscular wall continuous with a thin muscular investment of the ejaculatory duct. At its proximal end the prostatic vesicle narrows and as a curved duct connects with the relatively large seminal vesicle with thick wall of lengthwise muscle fibres. The seminal vesicle was cracked and distorted in the specimen, hence its contour in Figure 13 is conjectural.

The female gonopore lies not far behind the male pore. The small female antrum ascends and shows a constriction before opening into the vagina. The latter is a fairly wide tube with ciliated epithelium underlain by a moderately thick layer of circular fibres and receiving a cloud of cement glands. The vagina as usual ascends, then curves backwards and descends, receiving the common stem of the uteri. Beyond this point it continues as a short duct with beaded interior that soon enters the lower part of the very small, oval, erectly oriented Lang's vesicle.

Notoplana longiducta is distinguished by the very long sinuous ejaculatory duct between the prostatic vesicle and the penis and further by the small, vertically oriented Lang's vesicle.

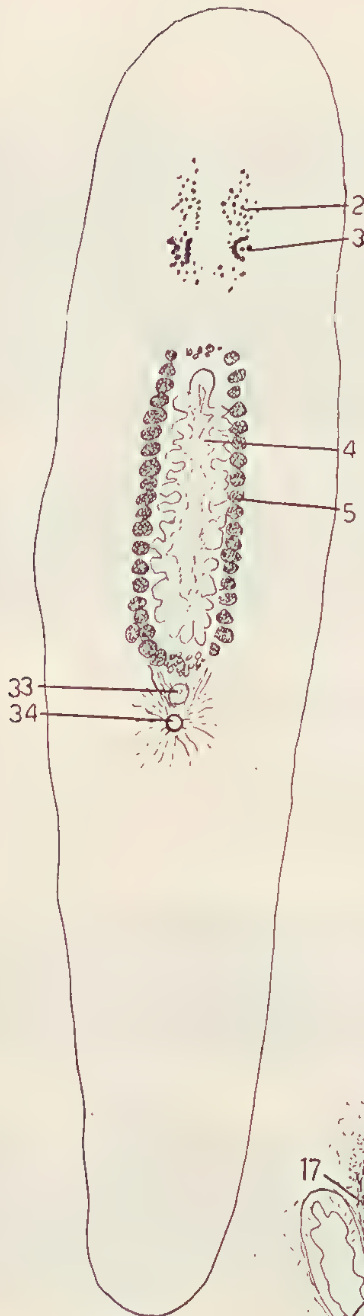
Holotype: Anterior part as whole mount, copulatory region as sagittal serial sections (3 slides) deposited in the Australian Museum; further, the second specimen mounted entire. [Reg. Nos.: Holotype W.3693; second specimen W.3694.]

Family **Callioplanidae** Hyman, 1953

Schematommata of oval form and firm consistency, with or without tentacles; with cerebral and tentacular eye clusters; pharynx ruffled; with true seminal vesicle; prostatic vesicle free, sometimes chambered; Lang's vesicle usually present, single or double.

Genus **Callioplana** Stimpson, 1857

Callioplanidae with prominent tentacles, well-developed penis papilla, and pair of Lang's vesicles extending anteriorly.



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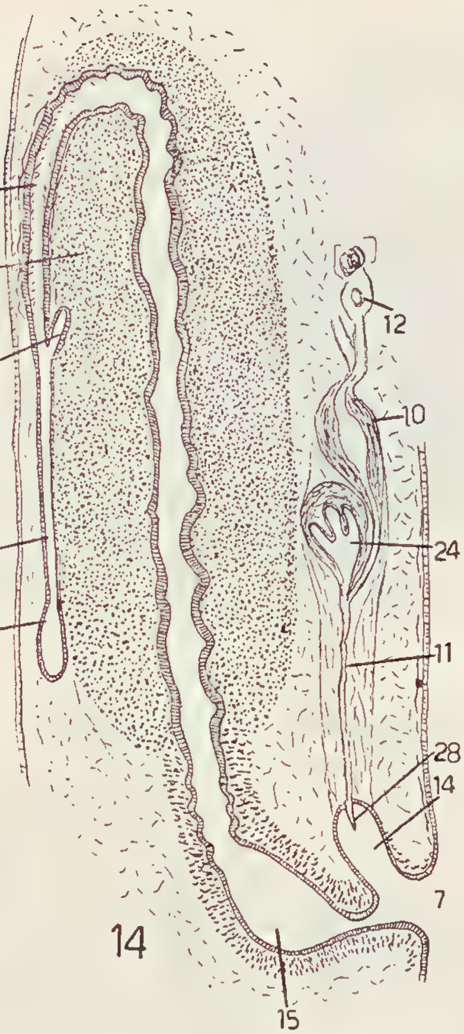
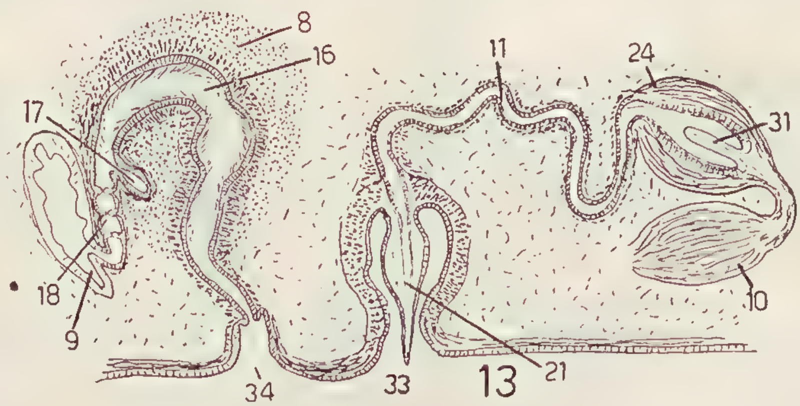




Figs. 12 to 13.—*Notoplana longiducta.* 12. Cleared whole worm, showing general features. 13. Sagittal view of copulatory complex, anterior end to right.

Fig. 14.—*Pseudostylochus bellus*, sagittal view of copulatory complex, anterior end above.

Key for anatomy: 2. cerebral eyes; 3. tentacular eyes; 4. pharynx; 5. uteri filled with eggs; 7. common gonopore; 8. cement glands; 9. Lang's vesicle; 10. seminal vesicle; 11. ejaculatory duct; 12. spermiducal vesicle; 14. male antrum; 15. female antrum; 16. vagina; 17. common stem of uteri; 18. duct of Lang's vesicle; 21. penis papilla; 24. prostatic vesicle; 28. penis stylet; 31. projection of ejaculatory duct into prostatic vesicle; 33. male gonopore; 34. female gonopore.

Callioplana marginata Stimpson, 1857

Stylochus oxyceraeus Schmarda, 1859.

Diplosolenia johnstoni Haswell, 1907.

Callioplana marginata, Yeri and Kaburaki, 1918.

The collection contains two specimens of this well-known species, a small and a large one. The latter is of oval form, with slightly frilled margin, 38 mm long by 20 mm wide. Schmarda (1859) and Haswell (1907) gave the dimensions as 60 by 30 mm, Yeri and Kaburaki (1918) as 50 by 30 mm. Schmarda's coloured figure depicts the dorsal surface as almost black with a red margin. Haswell described the colour as almost black with a narrow light margin. In Kato's 1944 description the colour is given as velvety black with a colourless margin subtended by a band of tawny brown. Miss Pope's description and colour sketch give the dorsal surface as sepia brown with a white margin subtended by an orange brown band to the inner side of which the sepia brown is somewhat deepened. Evidently the colour varies somewhat but the general pattern is a dark dorsal surface with a contrasting tawny brown to orange margin bordered thinly by white. Dakin (1952) in his book *Australian Seashores* presents a photograph of the worm under the old Haswell name. The prominent tentacles are pale with a distal or middle band of brown, orange, or red.

Stummer-Traunfels (1933), reinvestigating the material of Schmarda (1859), first suggested the identity of *Callioplana marginata* and *Diplosolenia johnstoni*. As accounts of the sexual anatomy have been given by Yeri and Kaburaki (1918), Stummer-Traunfels (1933), and Kato (1944), I have considered it unnecessary to make any sections, although Haswell's account is unclear and poorly illustrated. The species has been found at Japan, Ceylon, and south-eastern Australia. [Reg. Nos. W.3695, W.3696.]

Genus **Pseudostylochus** Yeri and Kaburaki, 1918

Callioplanidae with single Lang's vesicle.

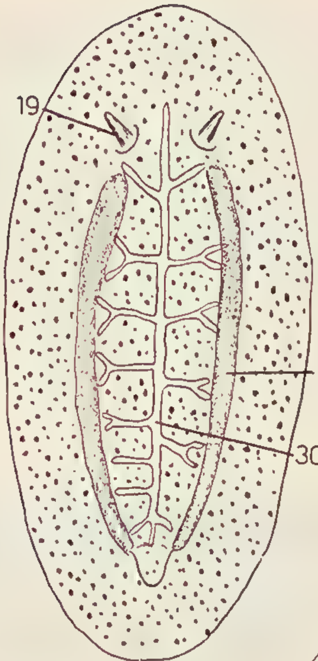
Pseudostylochus bellus, sp. nov.

(Figures 14-16)

The single specimen is of broadly oval form (Fig. 16), measuring 26 by 20 mm, but is evidently contracted as Miss Pope's colour sketch, redrawn as Figure 15, gives the shape as moderately oval. There is a pair of prominent tentacles with a ring of eyes at the base. It is rather interesting that Miss Pope noticed the resemblance to *Callioplana* in appearance, shape, and firm consistency. The colour of the dorsal surface is a light brownish-grey dotted with conspicuous rusty brown spots. The worm is described as a beautiful species, hence the specific name.

In the cleared entire worm (Fig. 16) are seen the tentacles, eyes, pharyngeal branches, mouth, and uteri filled with eggs. The tentacular eyes encircle the tentacle bases. The cerebral eyes occur in two loose clusters, one behind the brain, the other anterior to the brain. In the whole mount the ruffled pharynx is not clearly distinct from the intestinal branches which seem to have been plain in the living worm as a brown tree-like structure with the oval mouth somewhat posterior in position. The prominent coils of the uteri, bright orange in life, take a curved course alongside the pharynx on each side, and terminate anteriorly just behind the tentacles. Behind the pharynx is seen the great mass of cement glands, forming an apricot spot in life.

The usual sagittal serial sections were made of the copulatory region and a sagittal view of the copulatory complex is given in Figure 14. The small slender male apparatus, taking a horizontal course near the ventral wall, is overshadowed by the massive female apparatus that leans far forward above the former. The male apparatus is entered distally by the sperm ducts, narrowed after forming expansive spermiducal vesicles. They join at the seminal vesicle of fusiform shape with thick muscular wall. The ejaculatory duct issuing from its distal end is joined after a short course by the prostatic duct from the free prostatic vesicle, situated dorsal to it. The prostatic vesicle, of oval form with thick muscular wall, has a chambered interior, as also in a few other species of the genus. After receiving the prostatic duct, the ejaculatory duct runs posteriorly in a sheath of connective tissue to the male antrum where it projects as a small pointed penis stylet. The male antrum is a fairly deep rounded cavity that opens below in common with the female antrum by the common gonopore. The female antrum begins as a narrow passage that soon expands into a considerable cavity with strongly muscularized wall of circular fibres. This curves anteriorly and becomes the glandular vagina which pursues a long horizontal course in the anterior direction. In this horizontal course the vagina is entered by a tremendous mass of cement glands. After continuing anteriorly to a point considerably



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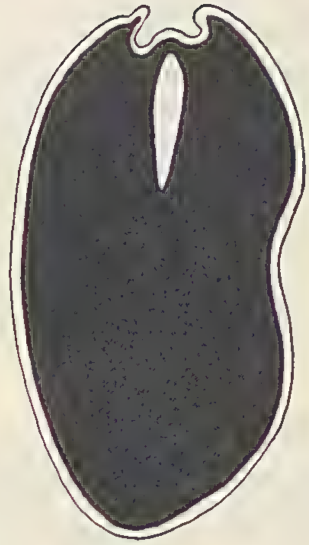

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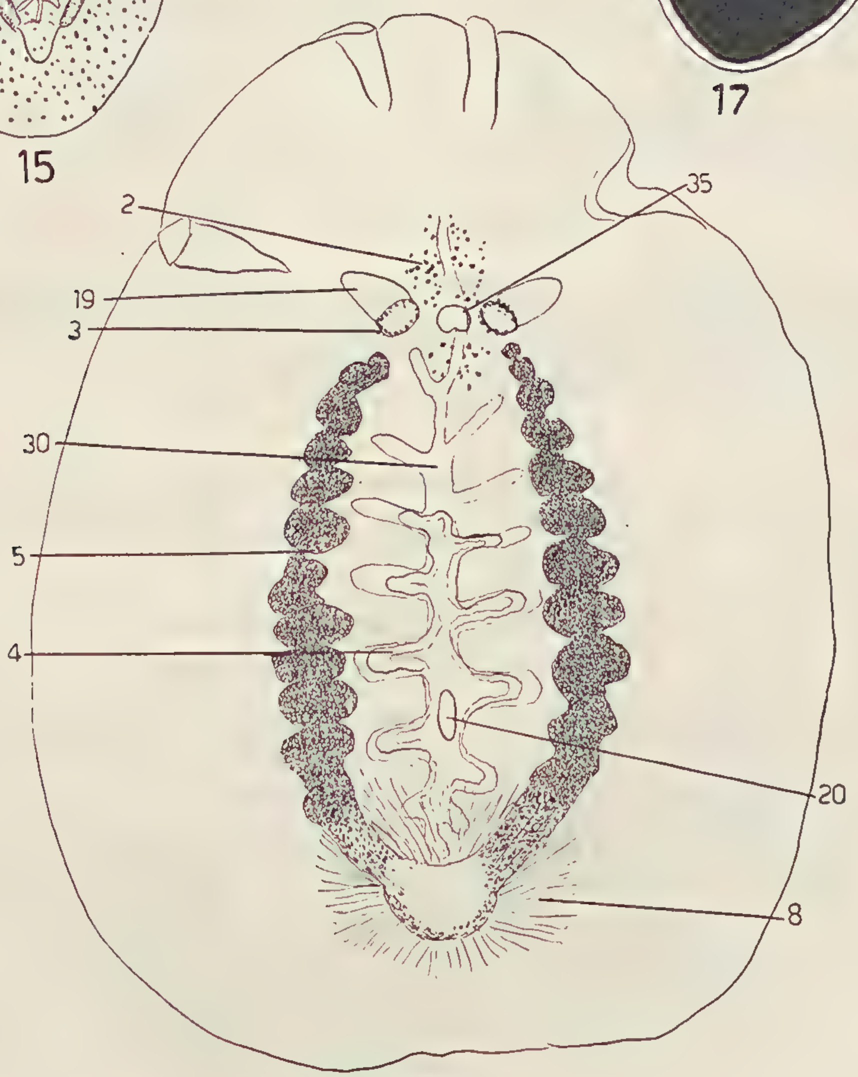

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Figs. 15 to 16.—*Pseudostylochus bellus*. 15. General appearance in life, after colour sketch by Miss Elizabeth Pope. 16. Cleared whole worm, showing general features.

Fig. 17.—*Pseudoceros albomarginatus*, after colour sketch by Miss Elizabeth Pope.

Key for anatomy: 2. cerebral eyes; 3. tentacular eyes; 4. pharynx; 5. uteri filled with eggs; 8. cement glands; 19. tentacles; 20. mouth; 30. intestine; 35. brain.

beyond the proximal end of the male apparatus, the vagina makes an upward and backward curve, then paralleling its previous course. After receiving from below the common stem of the uteri, the vagina continues posteriorly as a long slender duct of Lang's vesicle which terminates in a small oval sac.

Of the eighteen previously described species of *Pseudostylochus*, only one, *P. burchami*, from the Pacific coast of the United States (Hyman, 1953) also has conspicuous, projecting tentacles; but *P. bellus* differs from this altogether in the details of the copulatory complex, having a small penis stylet in place of a penis papilla, common gonopore (unusual in the genus), small chambered prostatic vesicle, in contrast to the large unchambered one of *P. burchami*, and much more massive and more anteriorly slanted female apparatus than *burchami*. All the other species inhabit Japanese waters, hence the present species greatly extends the range of the genus.

Holotype: One whole mount, copulatory region as serial sagittal sections (6 slides), deposited in the Australian Museum. [Reg. No. W.3697.]

Suborder Cotylea

Polyclads with a sucker behind the female gonopore (but sometimes wanting); tentacles when present of the marginal type (some exceptions); with cerebral and marginal eyes; marginal eyes in a pair of clusters on the anterior margin, associated with the tentacles when present, or as a short band along the anterior margin, sometimes along the entire margin; pharynx usually anterior, ruffled or tubular; when tubular directed forward; copulatory or prostatic apparatuses sometimes numerous; when single or paired in the anterior body half close to the pharynx with penis directed forward and uteri extending backward; prostatic vesicle free, rarely interpolated; Lang's vesicle almost always wanting.

Family Pseudoceridae Lang, 1884

Cotylea of oval or oblong shape with smooth or papillate dorsal surface and prominent marginal tentacles, formed of the upfolding of the anterior margin; pharynx ruffled, anteriorly located; intestinal branches numerous, anastomosing to a network; male copulatory apparatus single or paired, close behind or partly beneath the pharynx; penis usually armed with a short stylet; female apparatus single (rarely multiple in a longitudinal row); uteri when ripe greatly branched.

Genus **Pseudoceros** Lang, 1884

Pseudoceridae with smooth dorsal surface; male apparatus single or paired; female apparatus single.

Pseudoceros albomarginatus, sp. nov.

(Figures 17-18)

The single specimen was stated in Miss Pope's notes to be a strikingly handsome species, velvety jet black above with a white margin and a white blaze in the median anterior region. This pattern is shown in Figure 17, copied after Miss Pope's colour sketch. The ventral surface is dusky with a longitudinal white band running the entire body length. The tentacular folds on the anterior margin appear better developed in the preserved worm than in the colour sketch. The general form is oval; on preservation the margin was thrown into frills. The dimensions in life were not given but the preserved specimen is 16 mm long by 10 mm wide.

In the dehydrated cleared worm the heavy black pigment obscured most structures but main features could be discerned in the central white stripe. There are evident a few eyes on one of the tentacular folds, indications of the folds of the ruffled pharynx, the mouth, the single male gonopore, the female gonopore encircled by cement glands, and the sucker. The pores and sucker are more evident in alcohol. These features are shown in Figure 18 in their relative positions. The distance from the anterior margin to the male gonopore is 4.4 mm; from the male to the female gonopore, 0.5 mm; and from the latter to the sucker 1.6 mm. The sucker is thus located slightly anterior to the middle.

Of the many species of the genus *Pseudoceros* (over 100) there is only one other that is black with a white border, namely *P. bicolor* Verrill, 1901, from Bermuda. This, however, lacks median white markings and the black dorsal area sends out pointed rays into the white margin. The reproductive system of Verrill's species is unknown.

Holotype: The specimen in alcohol deposited in the Australian Museum. [Reg. No. W.3698.]

Family Diposthidae Woodworth, 1898

Cotylea with a pair of marginal tentacles of the euryleptid type, bearing eyes; also with cerebral eyes; with central ruffled pharynx; copulatory complex behind the pharynx, near the posterior end; prostatic vesicle in the male antrum, alongside the penis.

Genus **Diposthus** Woodworth, 1898

Diposthidae with the prostatic vesicle behind the penis; sucker wanting.

Diposthus popeae, sp. nov.

(Figures 19-21)

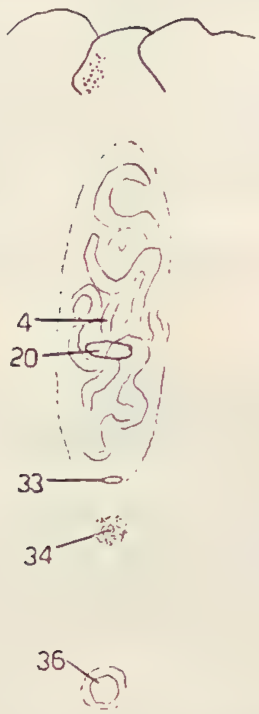
This species is reported as very common in the area. The collection contains four specimens, all distorted, and one in such bad condition that it was discarded. Miss Pope's notes state that the species is almost impossible to preserve. When handled it secretes quantities of mucus and fragments; further contracts and turns brown in the fixative.

In life the species is opaque white, of cuneate shape (Fig. 19) with a pair of pointed tentacles of the euryleptid type at the anterior margin. It is mostly around 15 mm in length. Preserved specimens are brown and distorted to a broadly oval shape as in Figure 20, measuring 11 by 10 mm. In the cleared specimen (Fig. 20) are seen the marginal eyes, in and around the base of the tentacles as paired clusters, the few cerebral eyes over the brain, the relatively large and greatly ruffled pharynx, the vagina behind the pharynx, and some very large eggs marking the course of the invisible uteri.

One of the specimens was sectioned sagittally but proved in such poor histological condition that it is unfortunately impossible to give a good account of the copulatory complex of this, the most interesting species in the collection. Especially the male complex is in poor condition. Immediately behind the pharynx is seen a cavity, the male antrum, containing a cylindroid penis papilla. No male gonopore was present but there was evidence that the male antrum connects by a tubular passage with the female antrum. However, evidence for such connection is so fragmentary it has not been included in Figure 21, which represents what could be seen of the copulatory complex. Above the penis papilla is an evident seminal vesicle with thick muscular wall and an exit curving down in the direction of the penis papilla. Alongside the seminal vesicle but not in the same plane is an oval body that might be a prostatic vesicle. The female system is better preserved. The female gonopore leads into a vertical female antrum from which the vagina ascends. At its beginning the vagina is entered on its anterior and posterior side by a distinct cement pouch that receives the cement glands. The vagina then ascends, and makes the usual backward and downward curve, terminating in an enlargement that was not clearly delineated in the sections. A possible duct enters this from before and very likely this enlargement receives the uteri. The latter were not definitely discernible but marked by a procession of remarkably large eggs. The vagina is lined by a tall scalloped epithelium underlain by a thin muscular stratum.

The present species is considered distinct from the only other species placed in the genus, *D. corallicola* Woodworth, 1898, in having a definite seminal vesicle and a pair of cement pouches. Woodworth claimed two seminal vesicles for his species but his figure shows that these are not seminal vesicles, but spermiducal bulbs, that is, muscular enlargements of the sperm ducts. Such spermiducal bulbs are definitely wanting in the present species as the spermiducal vesicles, or greatly expanded terminal parts of the sperm ducts, can be traced up to the male apparatus. Woodworth founded the genus and family on a projection that he termed prostatic vesicle paralleling the penis papilla in the male antrum. The nature of this projection remains uncertain and no such appearance could be found in the present specimen. Instead there was evidence of a fusiform body alongside the seminal vesicle that is probably a typical free prostatic vesicle as usual in Cotylea. Woodworth gives two figures of the vagina but does not indicate any cement pouches. He claims the presence of uterine vesicles and figures three pairs. I did not find any indications of uterine vesicles and wonder if Woodworth did not mistake the huge eggs for vesicles. Woodworth did not mention a sucker and this is definitely absent from the present species.

Holotype: The better of two specimens mounted whole on one slide; also set of sagittal serial sections (6 slides) deposited in the Australian Museum. [Reg. Nos.: Whole mount including holotype, W.3699; Serial sections, W.3700.]



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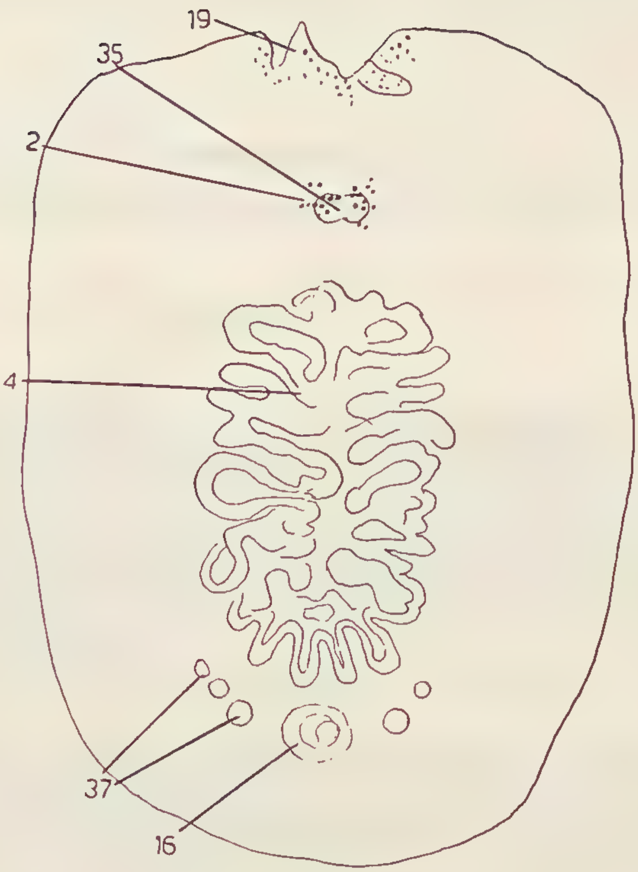

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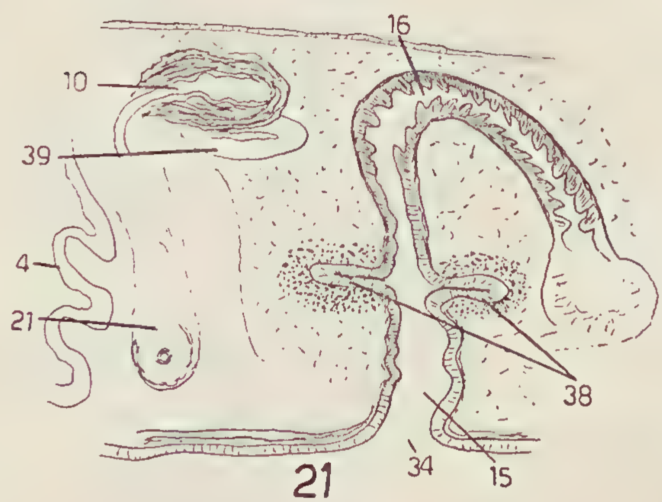

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Fig. 18.—*Pseudoceros albomarginatus*, central anterior region of cleared worm, showing pharynx, gonopores, and sucker, anterior end above.

Figs. 19 to 21.—*Diposthus popeae*. 19. Appearance in life, after colour sketch by Miss Elizabeth Pope. 20. Cleared preserved worm, showing general features. 21. Sagittal view of copulatory complex, imperfect from bad fixation, anterior end to left.

Key for anatomy: 2. cerebral eyes; 4. pharynx; 10. seminal vesicle; 15. female antrum; 16. vagina; 19. tentacles; 20. mouth; 21. penis papilla; 33. male gonopore; 34. female gonopore; 35. brain; 36. sucker; 37. eggs; 38. cement pouches; 39. prostatic vesicle.

CONCLUDING REMARKS

In the present collection there have been recovered only three of the eleven species mentioned in Haswell's well-known article (1907) on Australian polyclads, namely, *Enterogonia pigrans*, *Notoplana australis*, and *Callioplana marginata*. Others of Haswell's species need reinvestigation, notably *Echinoplana celerrima* which presumably belongs to the Planoceridae. Haswell reviews earlier findings from Australia. There has been no systematic collecting of polyclads along Australian shores since Haswell's work until the present collection and undoubtedly many species remain to be discovered there. In 1954, I added two cotyleans from the Great Barrier Reef, at Heron Island, namely *Pseudoceros bedfordi* and *P. corallophilus*. The present article adds seven species to the list from Australian shores: *Discocelis australis*, *Leptostylochus novacambrensis*, *Notoplana longisaccata* and *longiducta*, *Pseudostylochus bellus*, *Pseudoceros albomarginatus*, and *Diposthus popeae*. It is hoped the present contribution will stimulate further study of Australian polyclads.

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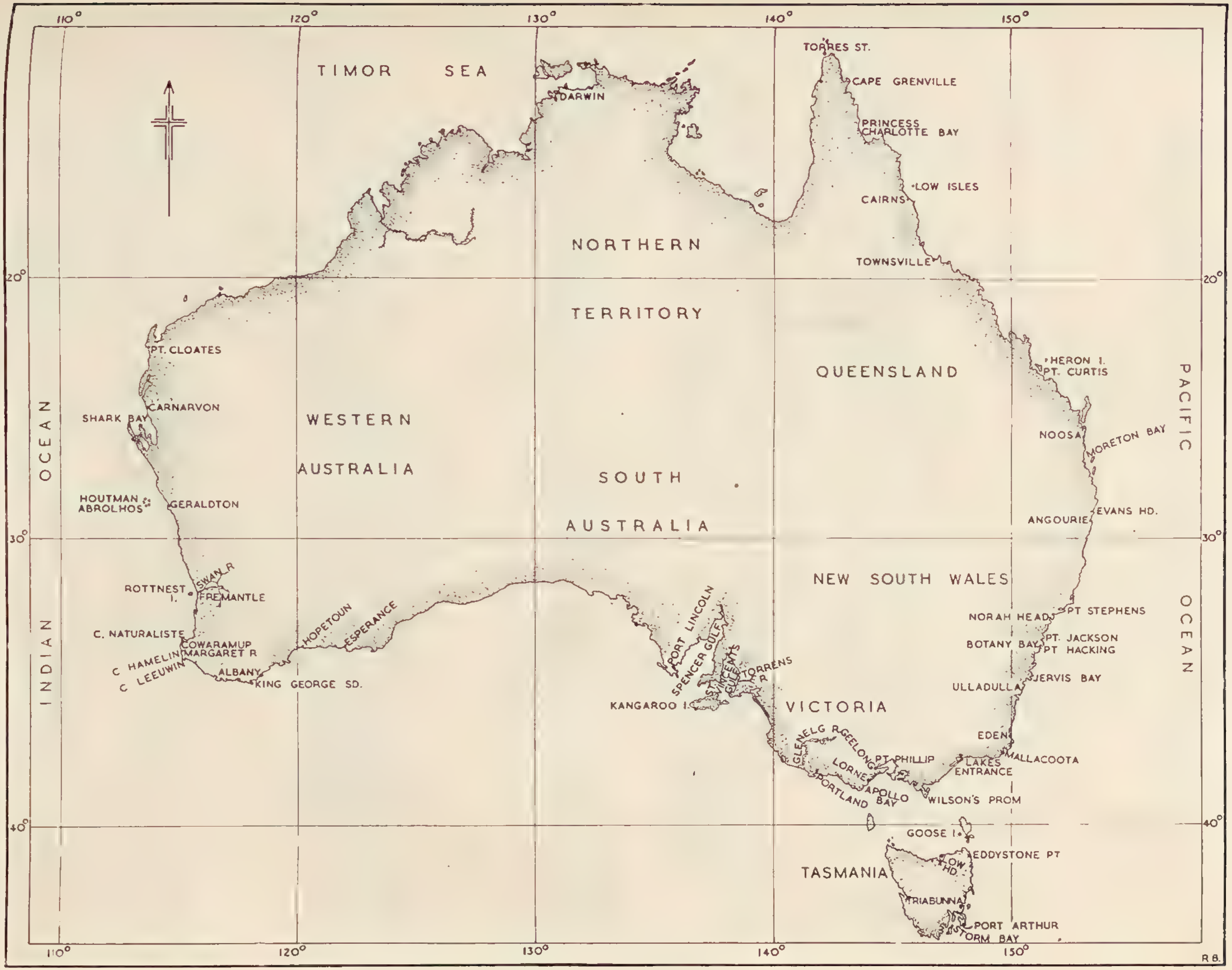

Fig 1: Map of Australia, showing localities mentioned in text.

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SERPULIDAE (POLYCHAETA) FROM AUSTRALIA

By Barbara Dew

(Figs. 1-21) Manuscript Received 30.9.58

INTRODUCTION

This study was part of the marine fouling programme (Allen and Wood, 1950) of the C.S.I.R.O. Marine Laboratory, Cronulla, New South Wales, Australia. This paper reviews most of the known Australian species, except the Spirorbidae, includes a key to the genera, gives full descriptions of the species and adds to the knowledge of Serpulid distribution.

MATERIALS AND METHODS

The material was collected from panels exposed at marine fouling stations on the coasts of Queensland and New South Wales and at Rabaul, New Britain; from wharf piles and under rocks on the coasts of all States of Australia (Fig. 1), and from the Solomon Islands.

The distribution of each species is given. It indicates the localities from which the material examined in this investigation was collected and also the distribution given by previous authors.

The worm tubes were carefully removed from the substratum and, where possible, fresh material was immediately examined. To preserve specimens, the worms were narcotized with menthol or magnesium chloride, or were allowed to become moribund in stagnant sea water. The extended worms and their tubes were then preserved in 70 per cent. alcohol. The setae and uncini were dissected out and cleaned in Gaiter's Medium (gum Arabic 50g, chloral hydrate 100g, glycerine 40ml, distilled water 100ml).

TAXONOMY

Family **Serpulidae**

Body divided into thorax, usually three to seven segments, bearing dorsal capillary setae and ventral uncigerous tori, and the abdomen, bearing ventral capillary setae and dorsal uncigerous tori (Fig. 2); first thoracic segment with collar; thoracic membrane present; branchiae forming a funnel around the mouth and composed of two spiral lobes or semicircles bearing a number of filaments with two rows of barbules; operculum usually present; tube calcareous and usually attached.

KEY TO GENERA

1.		Body symmetrical	2
		Body asymmetrical, calcareous tube spirally coiled	Spirorbis
2.	(1)	Operculum present	3
		No operculum, or an operculum on a branchial filament	13
3.	(2)	Collar setae present	4
		No collar setae	11
4.	(3)	Collar setae with two conical processes at the base of the blade	5
		Collar setae without processes	6
5.	(4)	Operculum a simple funnel	Serpula
		Operculum a funnel with a crown of spines	Hydroides
6.	(4)	Operculum stalk smooth	7
		Operculum stalk winged	8

7. (6) Operculum vesicular and armed with hooks; collar setae deeply serrated .... MERCIERELLA
Operculum horny, with a conical or cylindrical cap; collar setae not serrated .... VERMILIOPSIS
8. (6) Collar setae very small and fine 9
Collar setae bayonet-like 10
9. (8) Operculum flattish with movable calcareous spines .... GALEOLARIA
Operculum conical or bearing non-movable processes .... POMATOCEROS
10. (8) Operculum very variable in shape .... POMATOSTEGUS
Operculum with a calcareous plate and spiny processes .... SPIROBANCHUS
11. (3) Operculum stalk winged .... POMATOLEIOS
Operculum stalk smooth 12
12. (11) Tube attached to substratum .... PLACOSTEGUS
Tube free .... DITRUPA
13. (2) No operculum 14
Operculum carried on the end of a branchial filament 15
14. (13) Tubes colonial and fine .... SALMACINA
Tubes single and large .... PROTULA
15. (13) Tubes single and very fine .... JOSEPHELLA
Tubes single and large .... APOMATUS, f.

f Indicates that no specimens were collected or examined. The writer believes that representatives of these genera will ultimately be found in Australian waters.

LIST OF DESCRIBED SPECIES

[Specimens have been deposited in the Australian Museum, and the registered numbers of the collection are indicated below. Duplicates have also been sent to the British Museum (Natural History).]

	AUST. MUS. REGISTERED NO.
Serpula vermicularis Linnaeus 1767	W.3623
Hydroides norvegica Gunnerus 1768	W.3624
Hydroides novea-pommeraniae Augener 1924	W.3625
Hydroides exaltatus (Marenzeller) 1885	W.3626
Hydroides brachyacantha Rioja 1941	W.3627
Mercierella enigmatica Fauvel 1922	W.3628
Vermiliopsis acanthophora Augener 1914	W.3629
Vermiliopsis globula sp. nov. (Holotype)	W.3630
Galeolaria caespitosa Lamarck 1818	W.3631
Galeolaria hystrix Mörch 1863	W.3632
Pomatoceros terrae-novae Benham 1927	W.3633
Pomatostegus stellatus (Abildgaard) 1789	W.3634
Pomatostegus polytrema (Philippi) 1844	W.3635
Spirobranchus giganteus (Pallas) 1766	W.3636
Ditrupa australis Bretnall 1921	W.3637
Ditrupa laeve (Brazier) 1878	W.3638
Ditrupa amphora sp. nov. (Holotype)	W.3639
Salmacina dysteri (Huxley) 1855	W.3640
Protula palliata (Willey) 1905	W.3641
Josephella marenzelleri Caullery and Mesnil 1896	W.3642

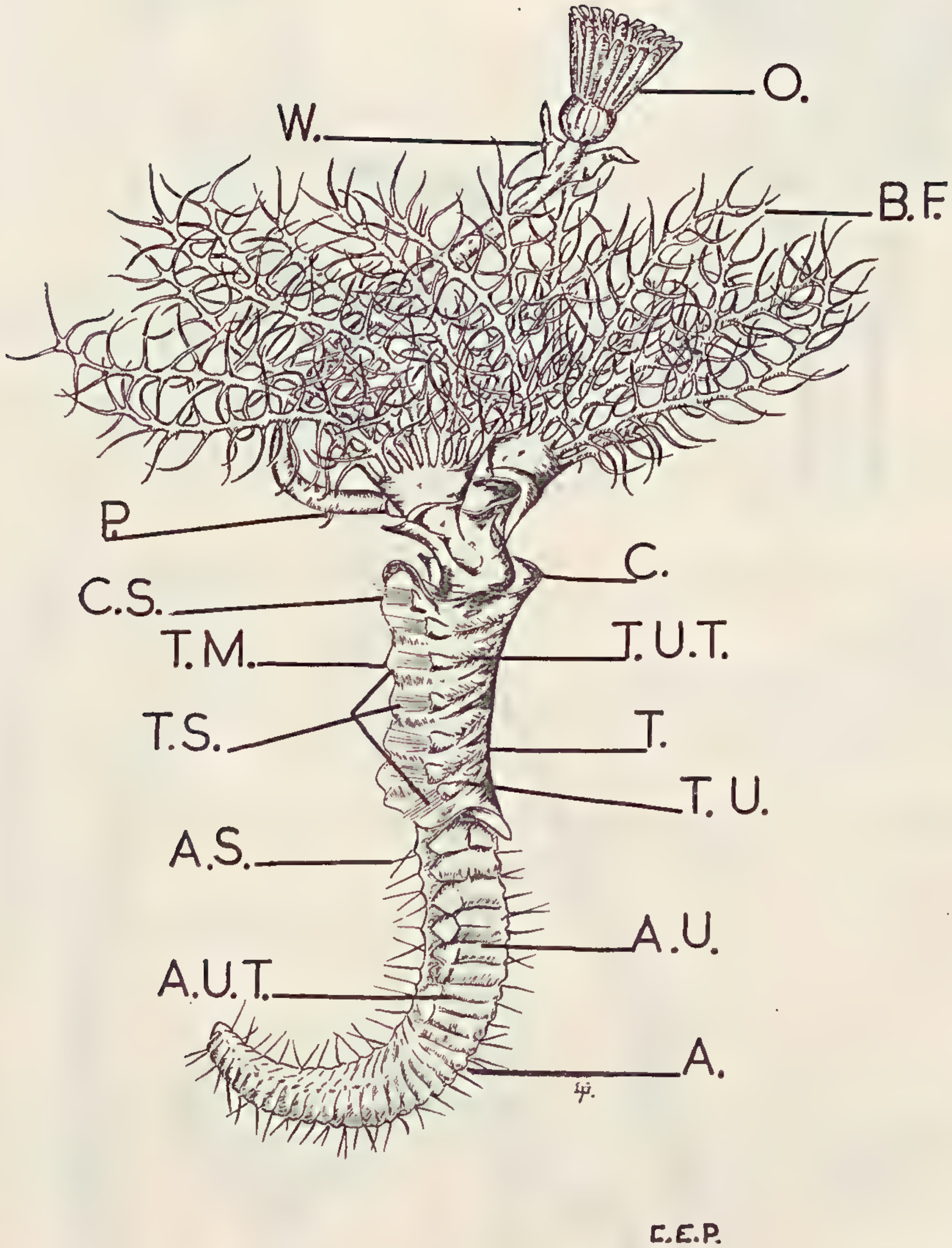


Fig. 2.—Diagrammatic figure showing the taxonomic characteristics of the family Serpulidae; A, abdomen; A.S., abdominal setae; A.U., abdominal uncini; A.U.T., abdominal uncinigerous tori; B.F., branchial filament; C, collar; C.S., collar setae; O, operculum; P, pedicle; T, thorax; T.M., thoracic membrane; T.S., thoracic setae; T.U., thoracic uncini; T.U.T., thoracic uncinigerous tori; W, wings.

Genus **Serpula** Linnaeus, 1758

Collar setae of two types, simple and bayonet-shaped, with two conical processes at base of blade; operculum a simple funnel, with numerous radii; thoracic setae winged, abdominal setae trumpet-shaped; uncini with few teeth, the most anterior stouter.

Serpula vermicularis Linnaeus, 1767

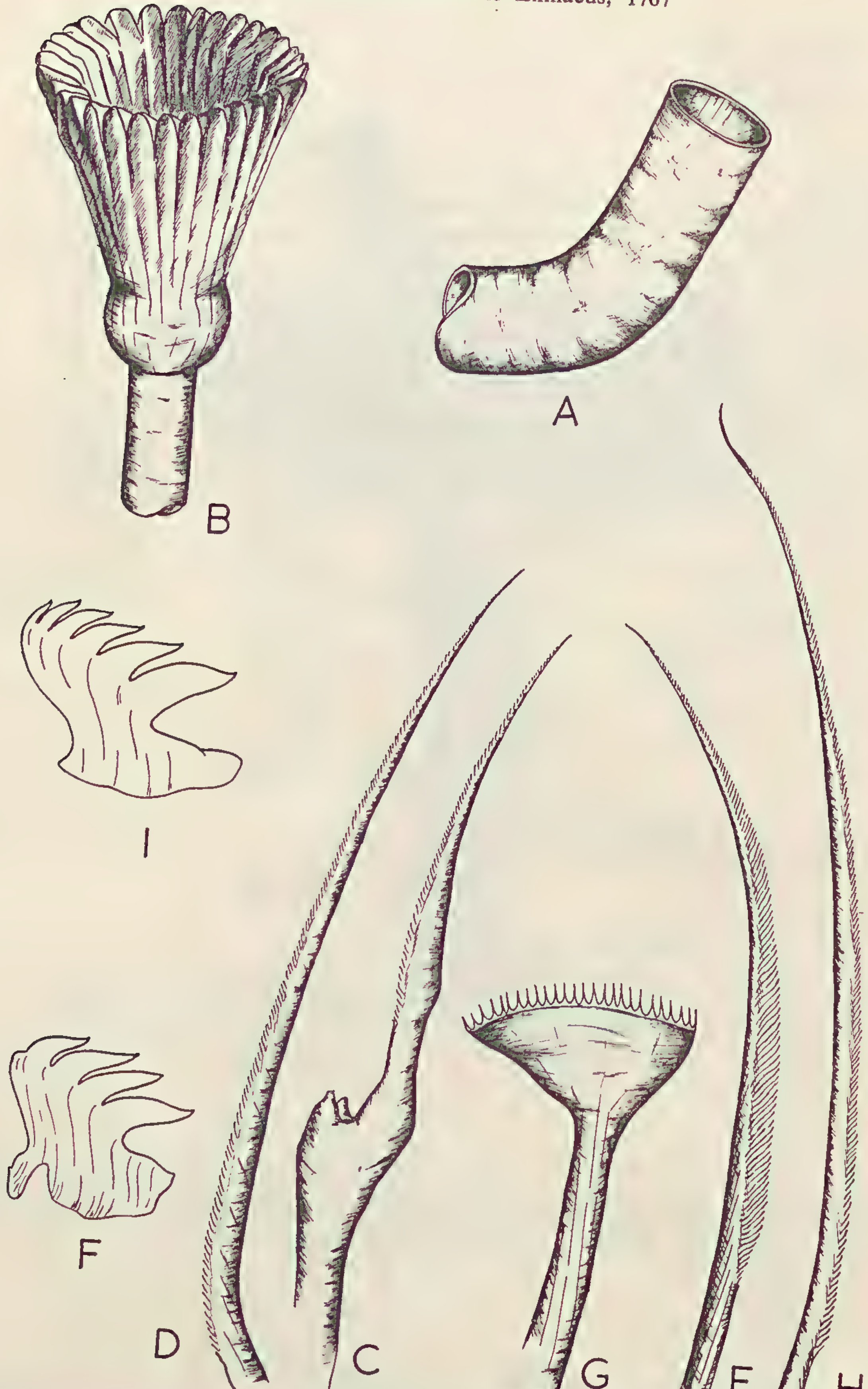


Fig. 3.—*Serpula vermicularis*: A, tube, x 18; B, operculum, x 30; C, D, collar setae, x 950; E, thoracic setae, x 475; F, thoracic uncinus, x 950; G, H, abdominal setae, x 950; I, abdominal uncinus, x 950.

Serpula vermicularis Linnaeus, 1767, p. 126; Augener, 1914, p. 133; McIntosh, 1923, p. 354; Fauvel, 1927, p. 351 (for synonymy).

Serpula jukesi Baird, 1865, p. 20.

Serpula zelandica Baird, 1865, p. 21.

Serpula vasifera Haswell, 1884, p. 668.

Tube.—White or yellowish, circular in section, with faint longitudinal ridge (Fig. 3A)

Branchiae.—Long, bearing a varying number of pinnae, with a long naked terminal filament, the number of pairs of filaments varying from 16 to 32, depending on age and length of individual; colour variable, usually a deep scarlet at base, becoming orange, tipped with yellow or white, regularly marked with narrow white bands; the simple operculum is carried on a smooth pedicle, which can arise from either branchial tuft; pedicle usually red, darker at base.

Operculum.—Funnel-shaped, with a varying number (15-80) of radii; outer edge crenated, degree of crenation (Fig. 3B) varying with age and length of individual specimen; usually whitish, but may be yellowish; rudimentary operculum usually present on opposite side.

Collar.—Tri-lobed, ventral lobe large and entire, lateral lobes uniting with thoracic membrane and extending on the ventral side to cover first few abdominal segments; the collar and thoracic membrane usually scarlet; setae a golden yellow; setae of two types—(1) simple and faintly serrated (Fig. 3D), and (2) bayonet-like with two conical processes at base of blade. (Fig. 3C).

Thorax.—Seven setigerous segments; the remaining six posterior segments have simple, winged striated setae (Fig. 3E); uncini with four to six teeth, the most anterior one being larger and stouter (Fig. 3F).

Abdomen.—Has large number of segments, frequently well over 100; setae trumpet-shaped, fine and short (Fig. 3G), except on posterior end, where there are a number of long simple setae (Fig 3H); uncini similar to those of thorax, but smaller and with a more flattened base (Fig. 3I); abdominal region pale yellowish, but when preserved in alcohol becomes a dull yellow-brown.

Material examined in Queensland (Thursday Island, Townsville, Heron Island); New South Wales (Angowrie, Norah Head, Port Jackson, Port Hacking).

Distribution.—Western Australia [Shark Bay, Geraldton, King George Sound, Champion Bay (Augener, 1914)]; Cosmopolitan.

Genus **Hydroides** Gunnerus, 1769

Collar setae of two kinds—(1) simple and (2) bayonet-shaped with two conical processes at base of blade; operculum a simple funnel with central crown of spines; thoracic setae winged, abdominal setae trumpet-shaped; uncini with few teeth, the most anterior being stoutest.

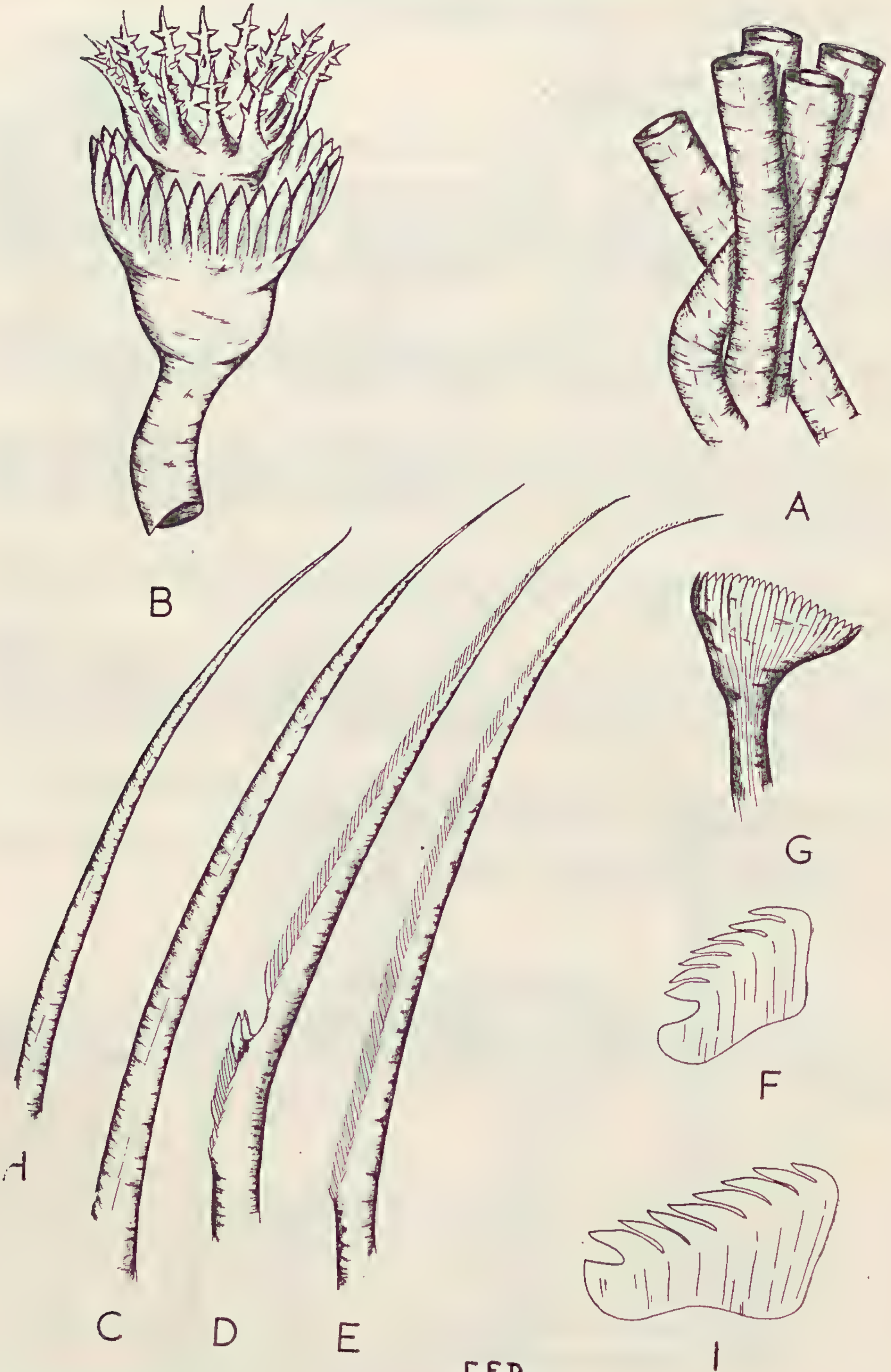
KEY TO SPECIES OF HYDROIDES

(1) Superior operculum spines all alike .... (2)
Superior operculum spines unlike .... (3)

(2) Superior spines with lateral processes .... *H. norvegica*
Superior spines without lateral processes .... *H. novae-pommeraniae*

(3) Similar operculum spines face inwards, no pronounced column .. *H. brachyacantha*
Similar operculum spines face outwards, pronounced column ....*H. exaltatus*

Hydroides norvegica Gunnerus, 1768



—*Hydroides norvegica*: A, tube, x 5; B, operculum, x 37; C, D, collar setae, x 475; E, thoracic setae, x 475; F, thoracic uncinus, x 950; G, H, abdominal setae, x 950; I, abdominal uncinus, x 950.

Hydroides norvegica Gunnerus, 1768; Pixell, 1913, p. 73; Fauvel, 1927, p. 356 (for synonymy).

Hydroides multispinosa Marenzeller, 1885, p. 216; Augener, 1914, p. 139, 1927, p. 273.

Eupomatus elegans Haswell, 1883, p. 633.

Tube.—White, circular in section, usually faintly marked with irregular growth rings; at first adherent to surface, later becoming erect and frequently intertwined. (Fig. 4A).

Branchiae.—11-14 pairs, each with a short terminal filament and numerous pinnae, variable in colour, with bands of contrasting colour along the axis; pedicle smooth, arising from either branchial tuft.

Operculum.—Complex, consisting of two superimposed cups, the lower somewhat funnel-shaped and having 23-32 crenulations, the superior arising from the centre of the lower and having a crown of sharp-pointed spines, each with sharp lateral processes (Fig. 4B); on the inner surface, along the mid-line, is a row of short projecting teeth; in the centre of the cup is usually a single short, sharp spine; rudimentary operculum normally present on opposite side, its state of development varying considerably.

Collar.—Entirely fused with the large colourless thoracic membrane; setae of two kinds—(1) simple (Fig. 4C) and (2) bayonet-like, with two conical processes at base of blade (Fig. 4D).

Thorax.—Seven setigerous segments, remaining six segments with simple faintly striated setae (Fig. 4E); uncini with six to seven teeth, the most anterior being stouter than the remainder (Fig. 4F).

Abdomen.—Setae trumpet-shaped (Fig. 4G); extreme end of the abdomen has long simple setae (Fig. 4H); uncini similar to those of thorax, but with eight to nine teeth. (Fig. 4I).

Discussion.—There is a surprising variation in colour, setae, and opercular structure, even within one clump of tubes. Although one operculum is usual, two are not uncommon Dew (1958). The number of lateral opercular spines also varies from three to five, both with and without further spines set at right angles.

In 1768 Gunnerus proposed a new genus, *Hydroides*, and, as the type of the genus, described *H. norvegica*. Since that date *H. norvegica* has been recorded and described under various names from many parts of the world. In 1885 Marenzeller described a single incomplete specimen and named what he regarded as a new species, *Hydroides multispinosa*, which was collected at low tide at Eno-Sima (Japan). All recent attempts to obtain similar specimens of this species from Japan have proved unsuccessful, but there seems little doubt that it is identical with *H. norvegica*.

In 1883 Haswell described a serpulid from Port Jackson under the name of *Eupomatus elegans*. He found that the species occurred in great numbers on algae in 10-12 fathoms and, rarely, on the underside of rocks.

In 1910 Fauvel claimed that, in this species, the number and shape of the setae and opercular spines varied with the age of the individual. This appears to hold for the material examined in this study. Fauvel (1932) notes that *H. multispinosa*, as described by Marenzeller, is the same as *H. norvegica;* Pixell (1913) and Augener (1927) have also suggested that *H. multispinosa* is synonymous with *H. norvegica*.

This species is one of the most important fouling organisms in Port Jackson and other ports. It occurs on ships, buoys and other floating structures, but rarely elsewhere, except powerhouses' water intake conduits in Port Jackson.

Material examined in Queensland (Townsville, Heron Island, Dunwich, Moreton Bay); New South Wales (Port Stephens, Port Jackson, Port Hacking, Jervis Bay, Ulladulla, Eden); Victoria (Geelong); South Australia (Port Lincoln); Western Australia (Fremantle); New Zealand (Auckland); New Britain (Rabaul).

Distribution.—Western Australia [Shark Bay (Augener 1914)]; Cosmopolitan.

Hydroides novae-pommeraniae Augener, 1924

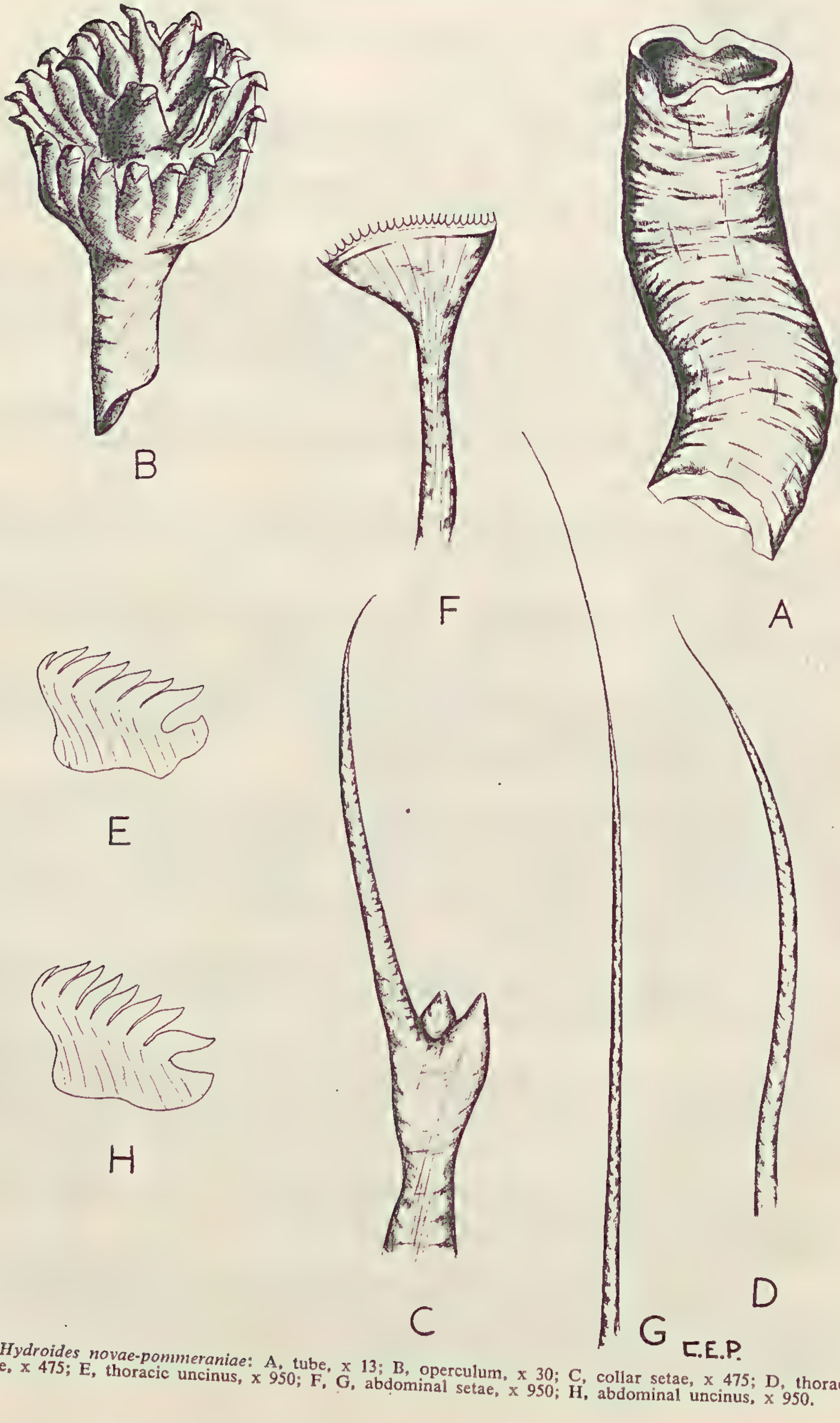


Fig. 5.—*Hydroides novae-pommeraniae*: A, tube, x 13; B, operculum, x 30; C, collar setae, x 475; D, thoracic setae, x 475; E, thoracic uncinus, x 950; F, G, abdominal setae, x 950; H, abdominal uncinus, x 950.

Hydroides novae-pommeraniae Augener, 1924, p. 17, Figs. 5, 5A.

Hydroides (*Eupomatus*) *novae-pommeraniae* Okada, 1937, p. 308.

Tube.—White, usually attached to a submerged object along its whole length; circular in section, with irregular growth rings and often with two irregular longitudinal ridges. (Fig. 5A).

Branchiae.—Seven to eight filamentous pairs, with a short terminal filament; operculum carried on smooth pedicle, which arises from either branchial tuft.

Operculum.—Complex, consisting of two superimposed cups; lower cup with twenty to twenty-three smooth spines, bearing everted tips; upper cup with seven short stout spines arising from a common base; spines of both cups terminating in sharp points (Fig. 5B). A rudimentary operculum is carried on the opposite side. An individual with two fully developed opercula was examined.

Collar.—Tri-lobed—one ventral, two lateral; the thoracic membrane extends downwards and covers first few abdominal segments; setae of two kinds—(1) fine capillary and (2) bayonet-like with two conical processes at the base of the blade (Fig. 5C).

Thorax.—Seven setigerous segments, remaining six segments with simple capillary setae (Fig. 5D); uncini with seven to eight teeth, the anterior tooth being much larger and blunter (Fig. 5E).

Abdomen.—Setae trumpet-shaped, with faint serrations (Fig. 5F); setae on terminal portion of abdomen simple (Fig. 5G); uncini vary slightly from those of thorax, having eight to ten teeth, the most anterior of which is larger (Fig. 5H).

Discussion.—This is the first report of this species from the Australian mainland. It occurred frequently on the "fouling" plates exposed at Townsville, Queensland, both mature and immature individuals being collected.

Material examined in Queensland (Thursday Island, Townsville).

Distribution.—New Guinea, Palau (Kororu) Island.

Hydroides exaltatus (Marenzeller), 1885.

Fig. 6.—*Hydroides exaltatus*: A, operculum, x 26.

Eupomatus exaltatus Marenzeller, 1885, p. 217; Pixell, 1913, p. 77, Pl. 8, Fig. 4; Willey, 1905, p. 312, Pl. VII, Fig. 182.

Hydroides (*Eupomatus*) *exaltatus* Augener, 1914, p. 142.

Tube.—White, circular in section, with few irregular growth rings, usually three but sometimes only one; longitudinal keel.

Branchiae.—13-15 filamentous pairs, with a clear, broken black line on their outer edge; short terminal filament; operculum pedicle smooth, arising from either branchial tuft.

Operculum.—Complex, consisting of two parts, the lower having 23-25 crenulations, from the off-centre of which arises a short stout column carrying seven or nine strong hook-like spines. Among these is a much larger dorsal one, bending over the others at almost a right angle (Fig. 6A); all spines lack lateral processes, except small ones on inner surface, close to base; a rudimentary operculum usually carried on opposite side.

Collar.—Setae of two kinds: (1) simple capillary and (2) bayonet-like, with two projecting conical processes at base of blade.

Thorax.—Seven setigerous segments; remaining six segments have simple winged setae; uncini have six to seven teeth, most anterior being stouter and larger.

Abdomen.—Setae trumpet-shaped, with end finely serrated; uncini similar to those of thorax.

Discussion.—A number of specimens of this species were collected in the Solomon Islands (Bougainville). They were removed from the shell of the Hammer Oyster (*Malleus vulgaris*), but the bodies, except for the opercula, were dried up.

Material examined in Queensland (Townsville) and Solomon Islands (Bougainville).

Distribution.—Western Australia (Shark Bay, Augener, 1914); Japan, Zanzibar, Ceylon, Red Sea.

Hydroides brachyacantha Rioja, 1941

Hydroides brachyacantha Rioja, 1941, p. 169, Pl. 3, Fig. 2, Pl. IV, Figs. 1-9.

Tube.—White, brittle and usually completely attached to substrate; two parallel ridges run the whole length of tube, enclosing a median longitudinal groove; groove and ridges not always conspicuous, sometimes absent (Fig. 7A).

Branchiae.—Twelve pairs, each with a long naked terminal filament, joined by a low interbranchial membrane; operculum pedicle smooth, arising from either branchial tuft.

Operculum.—Complex, consisting of two parts; lower cup crenated, having general shape of a horse's hoof; superior part arising from off-centre of the lower, normally consisting of nine stout inwardly-pointing spines, largest and stoutest of which curves over remaining eight, forming a cage. (Fig. 7B); remaining spines, except pair flanking large spine, have a blunt, tooth-like projection on shoulder of curve; operculum and pedicle about 4 mm in length; rudimentary operculum often present on opposite side.

Collar.—Tri-lobed, two lateral lobes joining single large ventral, then curling over top of thoracic membrane; setae of two kinds—(1) simple capillary (Fig. 7C), (2) large bayonet-like, with two marked protruding teeth at base of blade (Fig. 7D).

Thorax.—Seven setigerous segments; remaining six segments with simple, winged setae (Fig. 7E); uncini have five to six teeth, most anterior being much larger and stouter (Fig. 7F).

Abdomen.—Setae trumpet-shaped, finely toothed (Fig. 7G); uncini similar to those of the thorax (Fig. 7H).

Discussion.—This is the first record of this species from Australia, and the second world locality. The material from Townsville was removed from "fouling" panels, where it was quite plentiful; that from New South Wales occurred as numerous isolated examples on the under side of rocks.

Material examined in Queensland (Townsville), New South Wales (Botany Bay, Port Hacking).

Distribution.—Mexico.

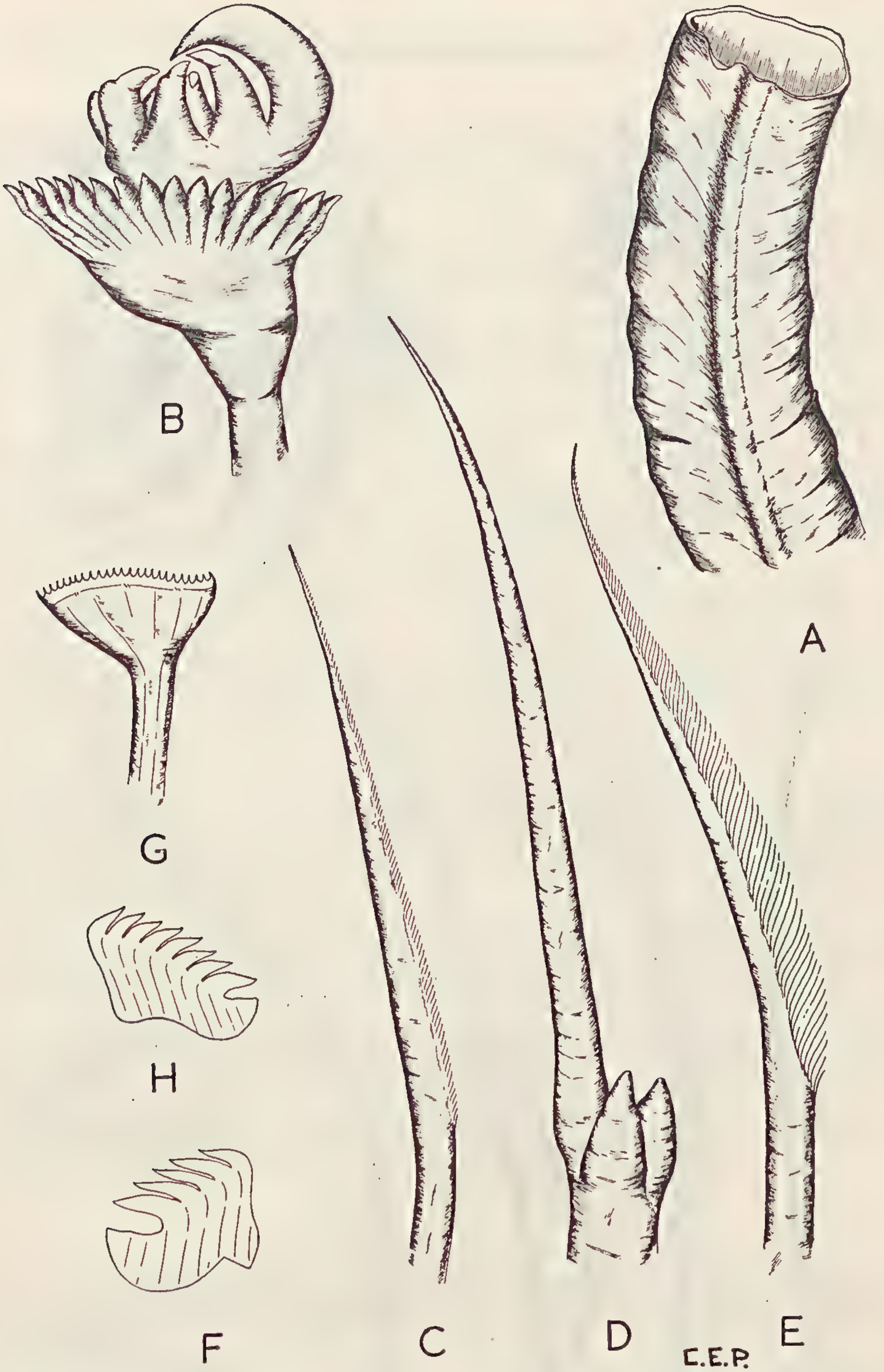


Fig. 7.—*Hydroides brachyacantha*: A, tube, x 13; B, operculum, x 16; C, D, collar setae, x 475; E, thoracic seta, x 475; F, thoracic uncinus, x 950; G, abdominal seta, x 950; H, abdominal uncinus, x 950.

Genus **Mercierella** Fauvel, 1922

Operculum vesicular, armed with chitinous hooks, borne on smooth pedicle; collar setae of two kinds—(1) simple, (2) deeply serrated; thoracic setae capillary, abdominal setae geniculate; uncini with few teeth, the last one being stouter and gouged.

Mercierella enigmatica Fauvel, 1922

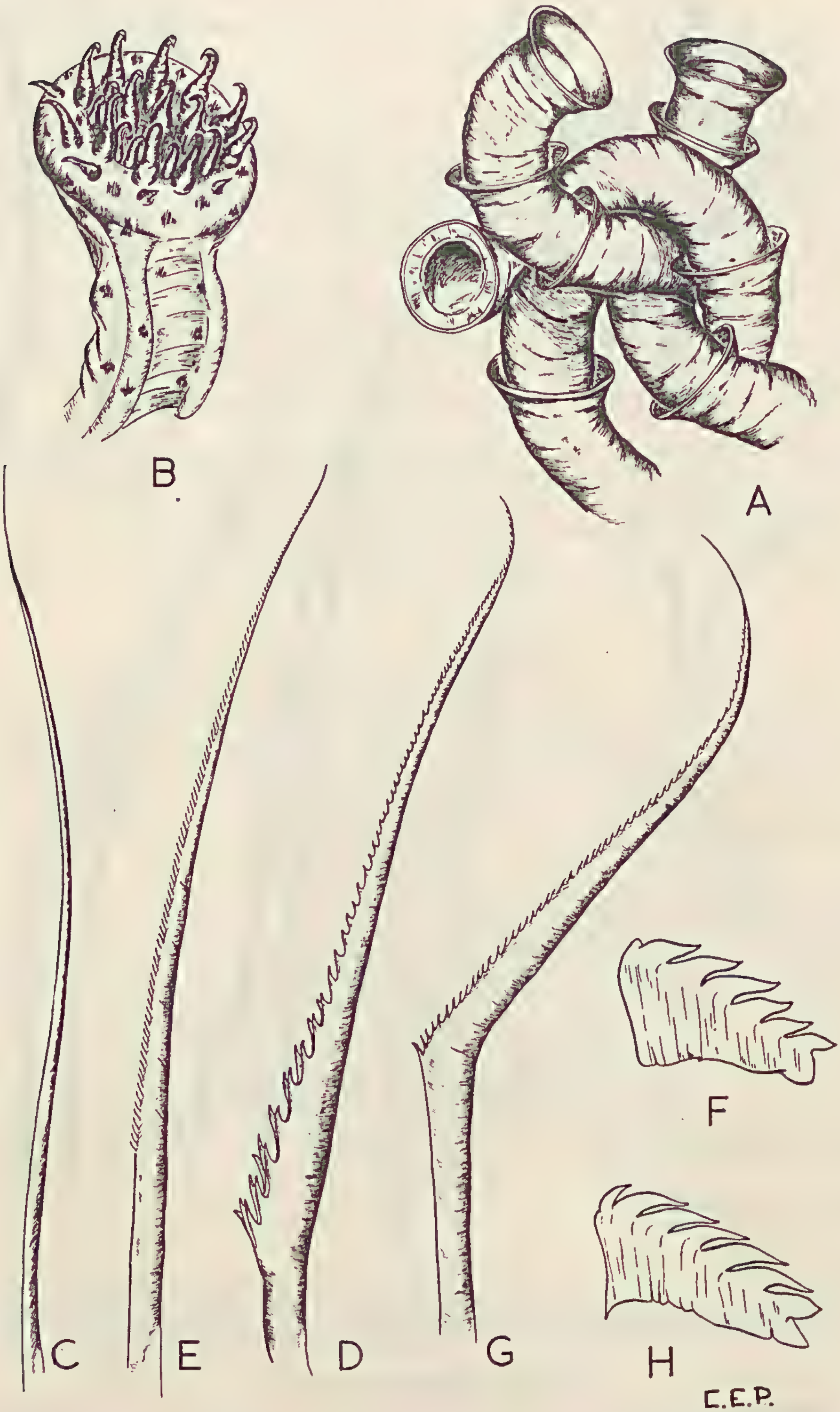


Fig. 8.—*Mercierella enigmatica*: A, tube, x 7; B, operculum, x 26; C, D, collar setae, x 475; E, thoracic seta, x 475; F, thoracic uncinus, x 950; G, abdominal seta, x 950; H, abdominal uncinus, x 950.

Mercierella enigmatica Fauvel, 1922, p. 425; Monro, 1924, p. 155; Fauvel, 1927, p. 359; 1932, p. 249; 1933, p. 185; 1935, p. 515; Monro, 1938, p. 624; Mensil and Fauvel, 1939, p. 37; Tebble, 1953, p. 1.

Tube.—White, but becoming yellowish-brown; circular in section; at irregular intervals "collar-like" outgrowths occur, giving a characteristic appearance (Fig. 8A); usually compact, forming dense "coral-like" masses; single tubes rare and tending to lack characteristic "collars".

Branchiae.—Usually nine pairs of eyeless filaments; terminal filament very long; interbranchial membrane completely absent; operculum with a smooth pedicle arising from the left branchial tuft; pedicle flattened, somewhat grooved on the dorsal surface, greenish-olive in colour, with a dark patch near base of operculum.

Operculum.—Non-calcareous, cone-shaped; somewhat vesicular; top slightly depressed, usually containing two concentric rows of chitinous hooks, outer of which stouter and darker in colour; number of hooks varies greatly, but averages about 20 (Fig. 8B).

Collar.—High, entire, and covering the base of the branchiae; setae of two types—(1) simple capillary (Fig. 8C), (2) deeply serrated, with a few rows of teeth set transversely at base and two long rows set longitudinally (Fig. 8D).

Thorax.—Thoracic membrane wide and frequently overlapping in the mid-line; dorsally and ventrally it overlaps the first few segments of abdomen; seven setigerous segments; remaining six segments have simple capillary setae (Fig. 8E). Uncini with six to seven teeth, most anterior being stouter and gouged (Fig. 8F).

Abdomen.—Setae geniculate and strongly toothed (Fig. 8G); uncini similar to those of thorax, but with seven to nine teeth (Fig. 8H).

Discussion.—This species was first noted in Cook's River, Botany Bay, during 1910, when it was observed to have formed dense coral-like masses; unfortunately no material was deposited in the Australian Museum, Sydney, at the time. The first written account is that of Monro (1938) from the Swan River (Western Australia).

The material found at Townsville (Queensland) usually occurred on the test plates exposed during the monsoonal periods of January-March. A few scattered individuals were also found if heavy rain fell during the non-monsoonal period. This was especially true during the very wet year of 1950. The tube structure of the Townsville specimens differs from those found in other parts of Australia as they lack the characteristic "collars", but this may be due simply to the fact that they were completely attached to the test panels and did not grow upright.

The worms grow very rapidly under certain conditions of salinity. Tebble (1953) found that below 25°/00 or at 57°/00, if the temperature exceeded 68°F., was especially favourable to rapid growth. A similar effect has been noted near Tempe, on Cook's River, Sydney.

Material examined in Queensland (Townsville, Noosa); New South Wales (Cook's River, George's River, Port Hacking); Victoria (Glenelg River, Newport); South Australia (River Torrens); Western Australia (Swan River, Carnarvon).

Distribution.—Europe, especially the Mediterranean countries; South Africa, India, North and South America. See Tebble (1953) for greater detail.

Genus **Vermiliopsis** Saint Joseph, 1906

Collar setae simple blades; uncini with fairly numerous teeth, the most anterior larger and blunter than the rest; abdominal setae geniculate; some thoracic setae of *Apomatus* type; operculum with a horny, somewhat cylindrical or conical, cap.

Key to Species of Genus Vermiliopsis

1. Operculum elongated, with numerous tiers .... *V. acanthophora.*
2. Operculum globular, without tiers .... *V. globula* n.sp.

Vermiliopsis Acanthophora Augener, 1914

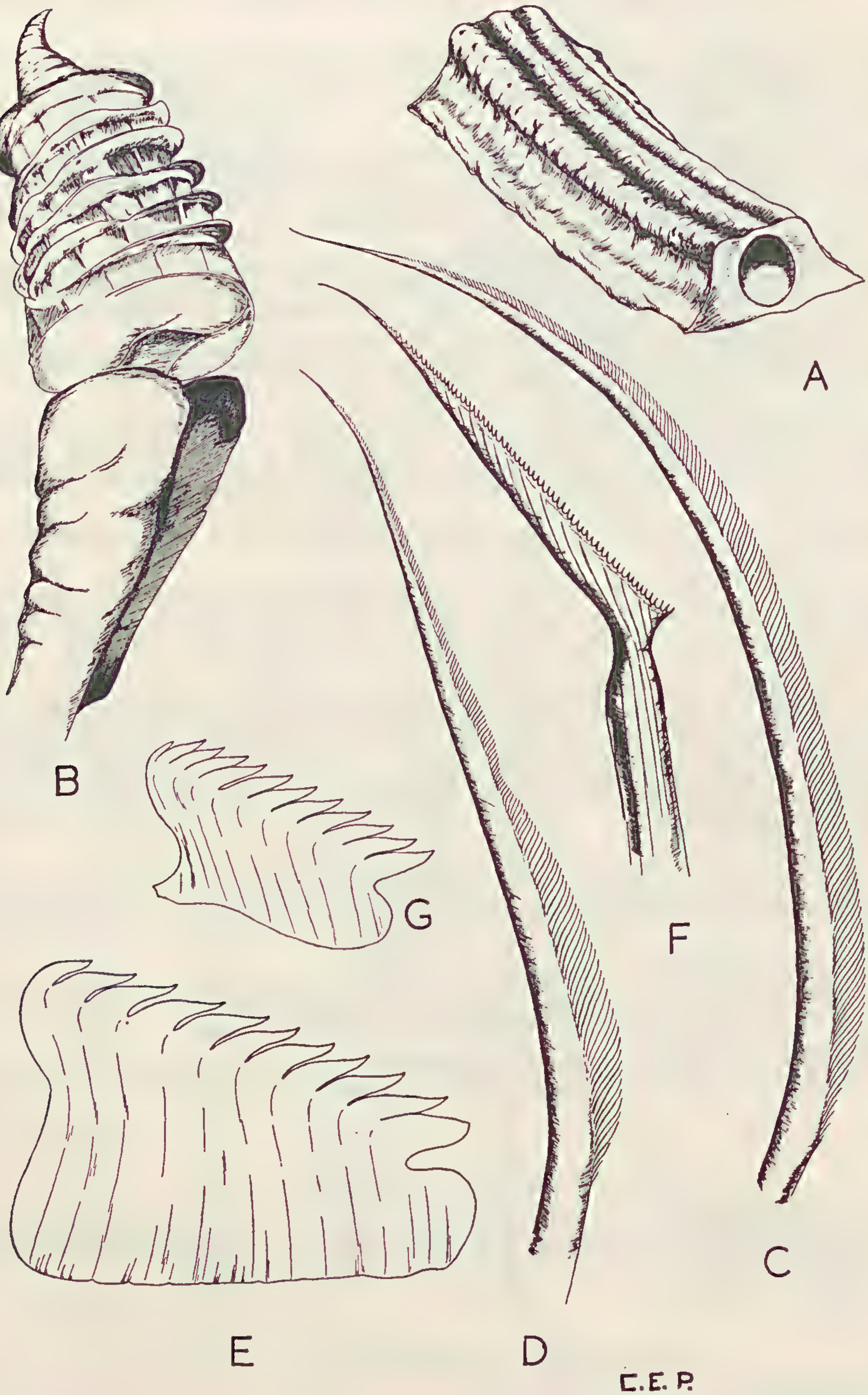


Fig. 9.—*Vermiliopsis acanthophora*: A, tube, x 20; B, operculum, x 33; C, collar seta, x 475; D, thoracic seta, x 475; E, thoracic uncinus, x 950; F, abdominal seta, x 950; G, abdominal uncinus, x 1800.

Vermiliopsis acanthophora Augener, 1914, p. 155, Pl. 1, Figs. 21-24; Fauvel, 1930, p. 63; Monro, 1937, p. 318.

Tube.—Whitish, frequently covered with a coating of yellowish brown alga; wall thick, somewhat trapezoid in section, with distinctly flattened top, and sometimes with a barely detectable ridge along the whole length; distinct thickenings occur transversely at very irregular intervals (Fig. 9A).

Branchiae.—Twenty pinnate pairs, with short club-like ends; pedicle whitish, stout and ribbon-like, with broad lateral edges, arising from right branchial tuft.

Operculum.—Whitish, soft near base where it joins pedicle, but this changes to brownish colour where it becomes chitinous; conical in shape, with four to six parallel layers of superimposed tiers; tiers unequally developed, especially those closest to base of operculum; only top two fully encircle cone, top one being best developed; top of operculum capped by single strong conical spine, with slightly curved tip (Fig. 9B); rudimentary operculum on left.

Collar.—Soft, appearing to be four-lobed, the ventral pair high and undulating; setae simple, winged, and faintly striated, few in number, small and fine (Fig. 9C).

Thorax.—Thoracic membrane well developed, covering thorax and first abdominal segment; seven setigerous segments; remaining six segments with stronger, stouter setae (Fig. 9D); uncini with 10-11 teeth, most anterior being noticeably stouter and blunter (Fig. 9E).

Abdomen.—Setae geniculate and finely toothed, the teeth reaching almost to end (Fig. 9F); uncini similar to those of thorax, but containing 12-13 teeth, most anterior being similarly stout (Fig. 9G).

Material examined in New South Wales (Norah Head, Port Jackson, Port Hacking).

Distribution.—Western Australia (Shark Bay, Augener 1914); Gulf of Manaar, Galapagos Islands, Gulf of Omana, Arabian Coast.

Vermiliopsis globula sp. nov.

(Fig. 10)

Tube.—White, heavy and solid, with a very marked, irregularly indented dorsal keel. (Fig. 10A).

Branchiae.—35 pinnate pairs, with shortish, naked, greenish-brown filaments; pedicle, somewhat triangular, is slightly swollen just before fusing with operculum, and arises from left branchial tuft.

Operculum.—Globular, with faintly striated cap, yellowish-ochre in colour; knob-like protrusion to one side of operculum (Fig. 10B).

Collar.—Well-developed, tri-lobed, single large ventral lobe distinctly divided from two laterals; centre of ventral lobe frequently folded into two triangular lappets; setae simple striated blades, tapering to a fine point (Fig. 10C).

Thorax.—Seven setigerous segments; thoracic membrane joins with that of collar, overlaps near collar but becomes progressively narrower towards posterior end; setae on remaining six segments of two kinds—(1) simple, like those of collar segment (Fig. 10D), and (2) simple winged, faintly striated; uncini with seven teeth, most anterior being stouter and blunter (Fig. 10E).

Abdomen.—Setae long, geniculate, finely toothed, terminating in a long fine point (Fig. 10F); few simple capillary setae on most posterior segments (Fig. 10G); uncini similar to those of thorax, with same number of teeth, slightly smaller in size (Fig. 10H).

Total length.—32 mm (thorax 4 mm, branchiae 5 mm, abdomen 23 mm).

Type locality.—Cronulla, N.S.W. Holotype in Australian Museum (Cat. No. W.3630), paratype in British Museum (Nat. Hist.) London.

Material examined.—New South Wales [Norah Head, Port Jackson, Cronulla (Port Hacking)].

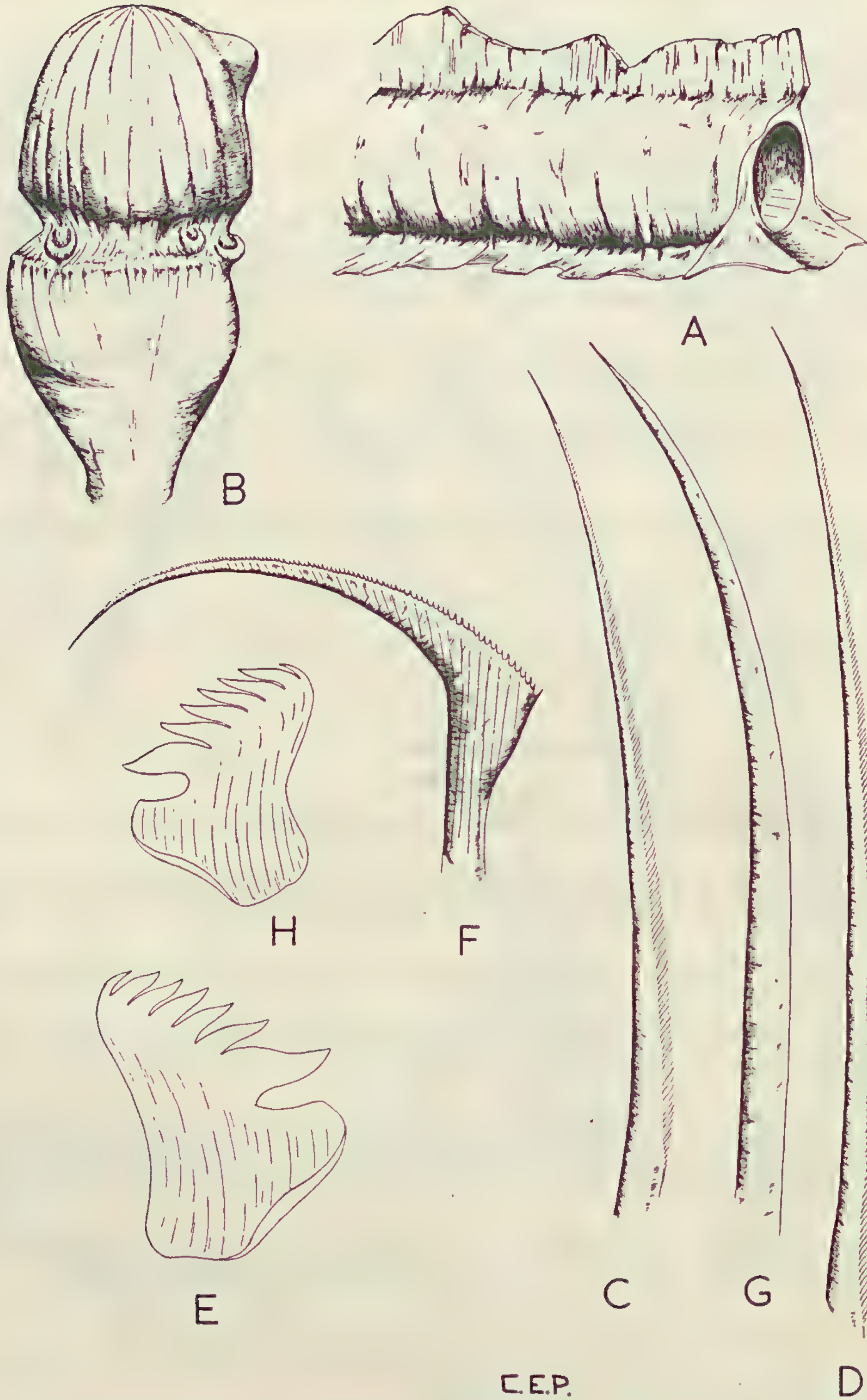


Fig. 10.—*Vermiliopsis globula*: A, tube, x 6; B, operculum, x 15; C, collar seta, x 475; D, thoracic seta, x 475; E, thoracic uncinus, x 950; F, G, abdominal setae, x 950; H, abdominal uncinus, x 950.

Discussion.—*Vermiliopsis globula* differs from *V. glandigerus* Gravier 1906 (from the Red Sea), which it most closely resembles and which has been recorded (Monro 1939) off the coast of Tasmania, in both shape and form of the tube and operculum. The tube of *V. globula* has one heavy well-developed ridge, while that of *V. glandigerus* has five longitudinal ridges of varying clarity. The operculum of *V. globula* is globular in shape, with longitudinal striae and a smooth, if somewhat swollen, pedicle. *V. glandigerus,* on the other hand, has concentric rings on both operculum and pedicle.

Genus **Galeolaria** Lamarck, 1818

Collar setae very short and fine; operculum consisting of calcareous plates, with movable spines; tube stout and with marked central keel; pedicle winged.

Key to Species of Galeolaria

1. Operculum with seven to nine movable calcareous spines .... *G. caespitosa*
2. Operculum with numerous movable calcareous spines .... *G. histrix*

Galeolaria caespitosa Lamarck, 1818

(Fig. 11)

Galeolaria caespitosa Lamarck, 1818, p. 636; Mörch, 1863, p. 368 (for synonymy); Augener, 1914, p. 145 (for synonymy); Pope, 1948, p. 235.

Vermilia caespitosa Haswell, 1884, p. 665 (for synonymy).

Tube.—White, cemented for most of length to substrate; usually found in colonies forming dense clumps or mats on rocks between tide levels; heavy and rough, with flattened grooved central keel which projects over the mouth. (Fig 11A).

Branchiae.—23 pairs, joined by a high interbranchial membrane, with prominent white band just below its free edge; short, with a very short terminal filament; colour variable, predominant colour greenish-olive with bands and blotches of black and white; pedicle short, blackish-green and winged.

Operculum.—Four (occasionally three) calcareous basal plates, surrounded by an outer fringe of small blunt processes; from base of basal plates arise nine (rarely 11) movable calcareous spines, each on its own base and capable of individual movement; the central spine is longest, smooth and tapers to blunt point; remaining four pairs of spines of two types—the outer pair smooth and terminating in a sharp point, the innter series, also pointed, all laterally toothed on one side and somewhat saw-like. the innermost pair shorter than the other spines, the outer pair being the longest (Fig. 11B).

Collar.—With a prominent white triangular lobe on upper ventral surface, deeply indented laterally; setae minute, very short and fine, and weakly striated at the edge (Fig. 11C).

Thorax.—Seven setigerous segments; the remaining six segments have more setae than the collar, similar but stronger, in bundles of 45 (Fig. 11D); uncini with seven to nine teeth, most anterior being stouter and grooved (Fig. 11E).

Abdomen.—Setae geniculate, with fine tapering points, lower edges being finely toothed. Two setae per bundle and two bundles per segment (Fig. 11F). Uncini with 11-15 teeth most anterior one being stouter and gouged (Fig. 11G).

Discussion.—This very common Australian species is popularly known as "Sydney Coral" (Pope 1948). It is usually found in a well defined belt or zone known to Australian shore ecologists as the *Galeolaria* Zone (Dakin, Bennett and Pope, 1948, pp. 196 and 211). This zone is mid-littoral, immediately above that of the ascidian *Pyura stolonifera.* The sharp demarcation is very obvious, and the thickness of the belt depends on the slope of the shore. On a vertical surface, such as a wharf pile, the band may be about two feet wide, but on a gentle slope, exposed to surf, it will be much wider, although remaining within the same tidal range. Occasionally, scattered individual tubes may be found outside this zone.

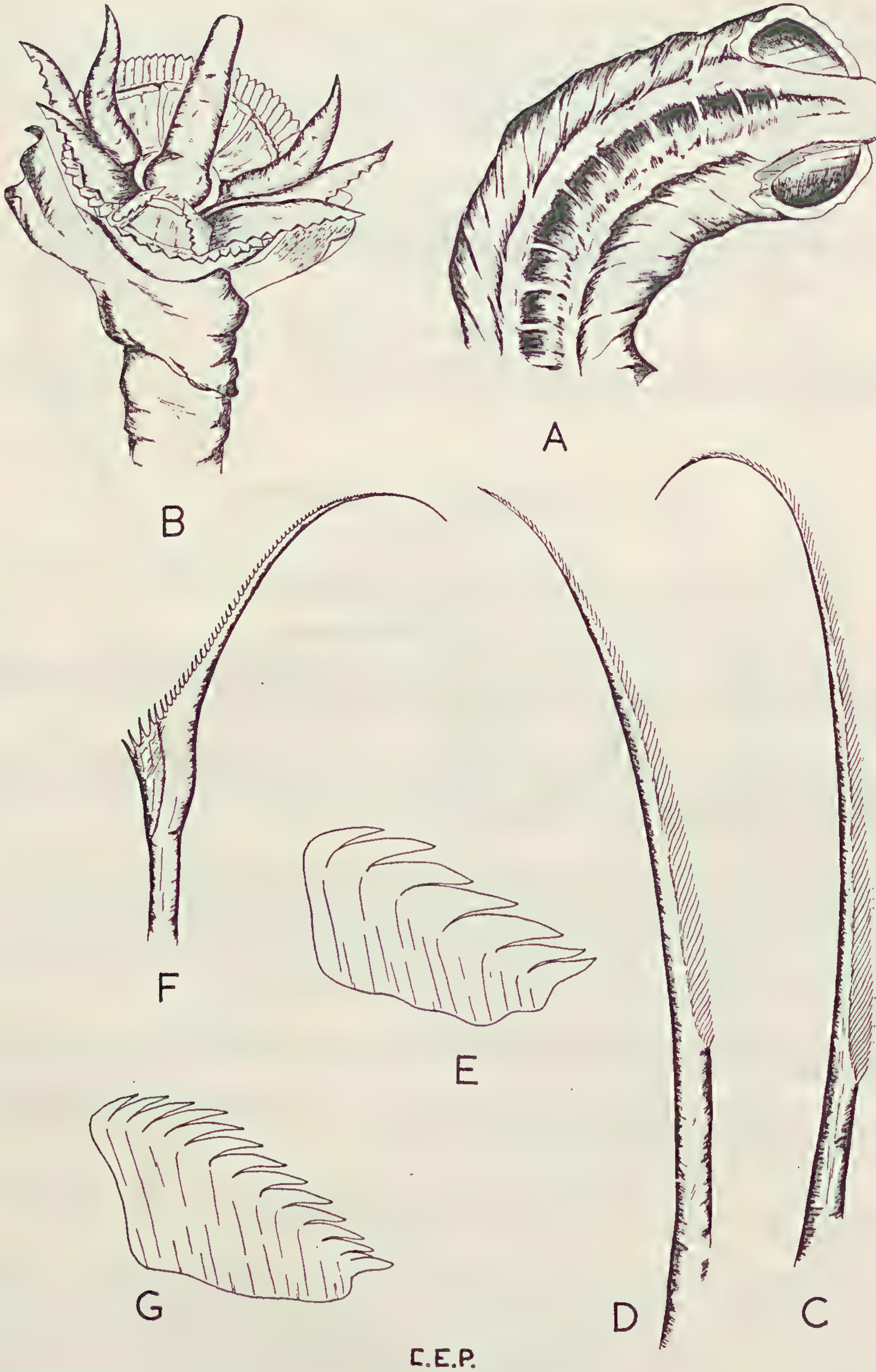


Fig. 11.—*Galeolaria caespitosa*: A, tube, x 17; B, operculum, x 21; C, collar seta, x 950; D, thoracic seta, x 475; E, thoracic uncinus, x 950; F, abdominal seta, x 950; G, abdominal uncinus, x 950.

Galeolaria is rarely found on floating surfaces, but isolated specimens have been obtained from ships in Sydney Harbour, especially those moored in Athol Bight. This species thrives best under conditions of normal salinity, and appears to tolerate only slight variation. It spends half of the day covered by the surge of the waves.

Galeolaria caespitosa was named by Lamarck (1818). Later, Quoy and Gaimard (1830) made reference to a siphonophore *Beroide australis*, which Blainville (1834) subsequently called *Galeolaria australis*. Stechow (1921), realising that this was a siphonophore and not a tubeworm, changed its generic name to *Galetta* to avoid confusion with *Galeolaria*.

Material examined.—Queensland (Dunwich, Moreton Bay); New South Wales (Evans Head, Port Stephens, Norah Head, Long Reef, Port Jackson, Port Hacking, Wollongong, Shell Harbour, Kiama, Ulladulla, Bateman's Bay, Tollgate Islands, Jervis Bay, Eden); Victoria (Lakes Entrance, Wilson's Promontory, Tidal River, Phillip I., Rickett's Point, Lorne, Apollo Bay, Cape Otway, Portland, Nelsons Bay); South Australia (Port Lincoln, Kangaroo Island); Tasmania (Port Arthur, Low Head, Eddystone Point, Cape Sorell, Goose Island); Western Australia (Esperance, Hopetoun, Albany, Cape Leeuwin, Hamelin, Margaret River, Cowaramup, Cape Naturaliste).

Distribution.—This species is endemic and occurs from Dunwich (Moreton Bay, Qld.) south and west to Cape Naturaliste (Western Australia) and also in Tasmania. It is plentiful on the ocean shores and extends into the numerous bays and harbours.

Galeolaria hystrix Mörch, 1863

(Fig. 12)

Galeolaria hystrix Mörch, 1863, p. 370; Ehlers 1907, p. 29; Fauvel, 1917, p. 269, Fig. XXIX (for synonymy).

Galeolaria rosea Ehlers, 1905, p. 20.

Eupomatus boltoni Baird, 1865, p. 12, Fig. 10.

Vermilia rosea Haswell, 1884, p. 667, Pl. xxxii, Fig. 2-5.

Tube.—Varying in colour from pale pink to deep rose, with two pronounced, irregularly serrated parallel ridges, enclosing a central grove (Fig. 12A).

Branchiae.—Short, 17 pairs, marked with bands of brown and red; interbranchial membrane present, joining bases of branchiae; pedicle winged, short, stout and flattened, the wings usually cut up into a number of short tooth-like projections.

Operculum.—With a number of small flattened calcareous plates, many of which carry movable calcareous spines; spines of two types—(1) smooth, (2) short, curved, toothed spines; outer circumference consists of row of short, blunt, radiating, calcareous spines; remaining spines arranged in two semi-circles, inner one consisting of long smooth spines with curved apices and outer series consisting of about 21 spines armed with five to six stout broad teeth (Fig. 12B).

Collar.—Tri-lobed, the two lateral lobes curling over on themselves while the single large ventral lobe is folded into a number of waves; setae fine and all of one type, blades simple with faint striation (Fig. 12C).

Thorax.—Seven setigerous segments: remaining six segments have setae similar to those of collar, except that they are more plentiful and stouter (Fig. 12D); uncini with six to seven teeth, most anterior being stouter and gouged (Fig. 12E).

Abdomen.—Setae are geniculate and finely toothed; there are two setae per tuft and two tufts per segment (Fig. 12F); uncini similar to those on thorax, but with six to eight teeth, most anterior being similarly gouged (Fig. 12G).

Discussion.—In Australia *G. hystrix*, unlike *G. caespitosa*, usually occurs as scattered individuals under rocks below low tide level, and is often found on the holdfasts of kelp (*Ecklonia radiata*) washed up after storms. *G. hystrix* is larger than *G. caespitosa*,

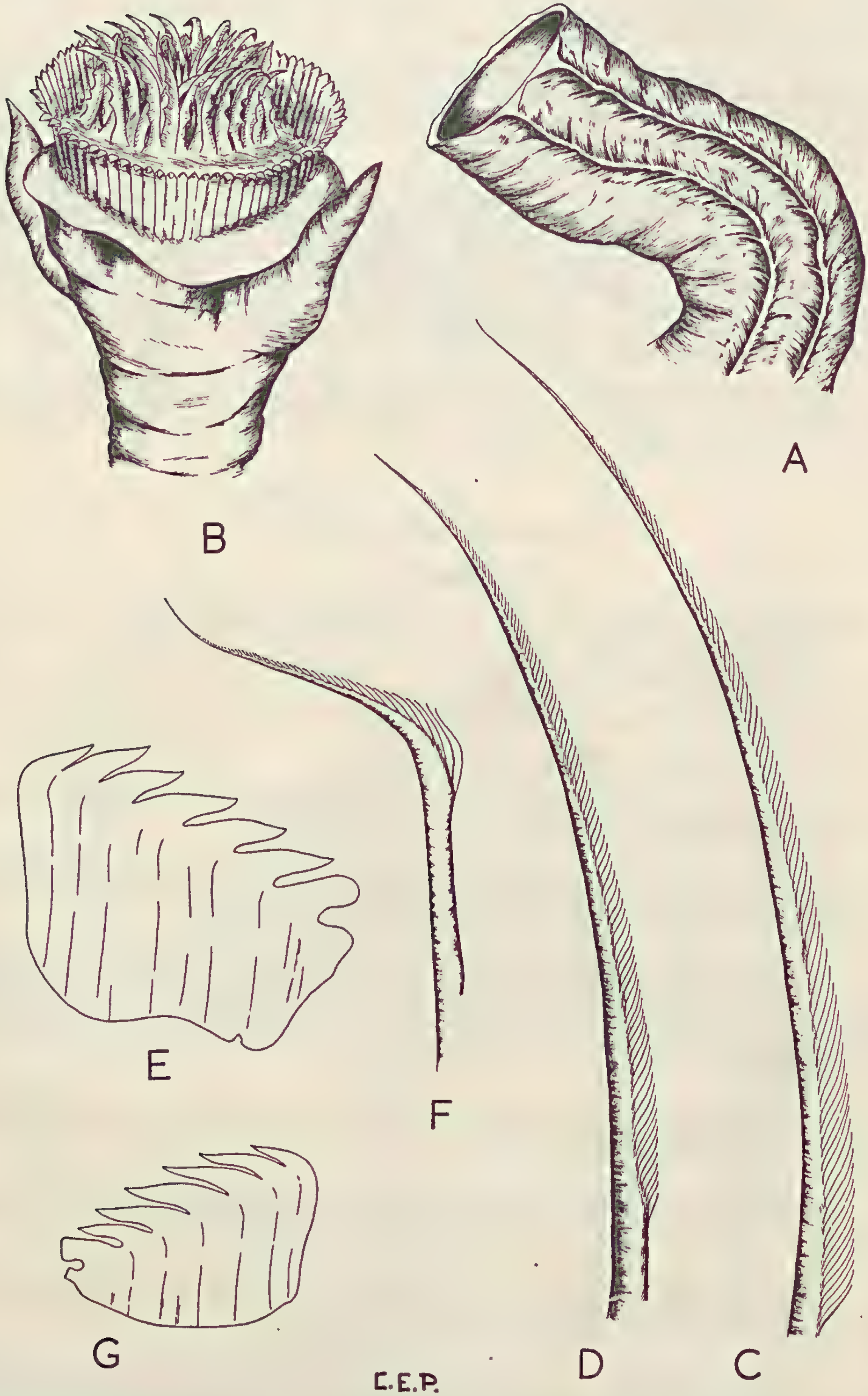


Fig. 12.—*Galeolaria hystrix*: A, tube, x 6; B, operculum, x 16; C, collar seta, x 950; D, thoracic seta, x 950; E, thoracic uncinus, x 950; F, abdominal seta, x 950; G, abdominal uncinus, x 950.

and an adult may measure up to 16 mm in length with a tube over 30 mm long. In New Zealand both tubes and worms are larger, a tube length of 68 mm being not uncommon and the worm being between 25-30 mm long. The tubes are also found in a different habitat (at Portobello), occurring in large numbers on the upper surfaces of rocks. The indented central keels are more pronounced than the local Sydney forms, and the colour is frequently a deeper rose-pink.

Material examined.—New South Wales (Port Jackson, Port Hacking, Jervis Bay); New Zealand (Portobello, Dunedin).

Distribution.—South Australia [St. Vincent's Gulf, Spencer Gulf (Fauvel, 1917)].

Genus **Pomatoceros** Philippi, 1844

Operculum terminated by a flat calcareous plate, very variable in shape, with or without spines; pedicle has broad lateral wings, faintly serrated on their free edges; collar setae very small, few in number; remaining thoracic setae limbate; abdominal setae compressed and trumpet-shaped, with a long terminal point; uncini have numerous teeth, most anterior teeth being gouged.

Pomatoceros terrae-novae Benham, 1927

(Fig. 13)

Pomatoceros terrae-novae Benham, 1927, p. 151, Pl. V, Figs. 174-180.

Tube.—White, with two more-or-less marked violet or lilac stripes running each side of a central keel; circular in section, with no definite shape, following undulations of substrata; the central keel is undulate, occasionally having quite well-defined, tooth-like processes (Fig. 13A).

Branchiae.—15 pinnate pairs, with naked terminal filaments; pedicle arising from either side is long, smooth and cylindrical, having a pair of thin, filamentous wings close to base of operculum.

Operculum.—Simple, membranous, somewhat like an inverted cone, with a thin, white calcareous plate on upper surface; plate is either flat or has a slightly raised projection (Fig. 13B); rudimentary operculum is present on the opposite side, and takes the place of a damaged or lost one.

Collar.—Tri-lobed; lateral lobes short, not extending far up the branchiae; single ventral lobe simple and sometimes with a peak at centre. Setae (usually about 10-12) of one type, winged, slightly curved, with faint, denticulate striations. Setae of two sizes, one set being much stouter than remainder (Fig. 13C).

Thorax.—Thoracic membrane joining that of collar, overlapping the first few segments of thorax and sweeping back to a blunt taper at rear; whole membrane short and fragile; seven setigerous segments; remaining six segments with setae similar to those of collar, but stouter and more numerous; last segments with fewer setae (Fig. 13D); uncini with 8-10 teeth, most anterior being stouter and blunter (Fig. 13E).

Abdomen.—First few segments devoid of setae; remaining segments with two setae per tuft and two tufts per segment; setae trumpet-like, with long terminal filament (Fig. 13F); uncini are similar to those of thorax (Fig. 13G).

Discussion.—This is the first record of this species from Australia. It is recorded in Australia as a fouling organism at Geelong and Port Lincoln. At Wilson's Promontory (Victoria) and Triabunna and Storm Bay (Tasmania) it was collected in the intertidal region, while the specimens from Port Curtis, Queensland, and Lakes Entrance, Victoria, were dredged from 10 and 50 fathoms, respectively.

Material examined in Queensland (Port Curtis), Victoria (Mallacoota, Lakes Entrance, Wilson's Promontory, Corio Bay, Geelong); Tasmania (Triabunna, Storm Bay); South Australia (Port Lincoln).

Distribution.—South Trinidad.

Genus **Pomatostegus** Schmarda, 1861

Operculum very variable in shape; pedicle with broad lateral wings; collar setae of two kinds, (1) simple, (2) bayonet-like, covered with fine, hair-like processes; abdominal setae sickle-shaped, i.e., *Salmacina* setae; uncini with about nine teeth, most anterior ones being larger and gouged out underneath; uncinigerous tori of right and left side almost meeting on ventral side of thorax, leaving only a narrow straight depression along medial line.

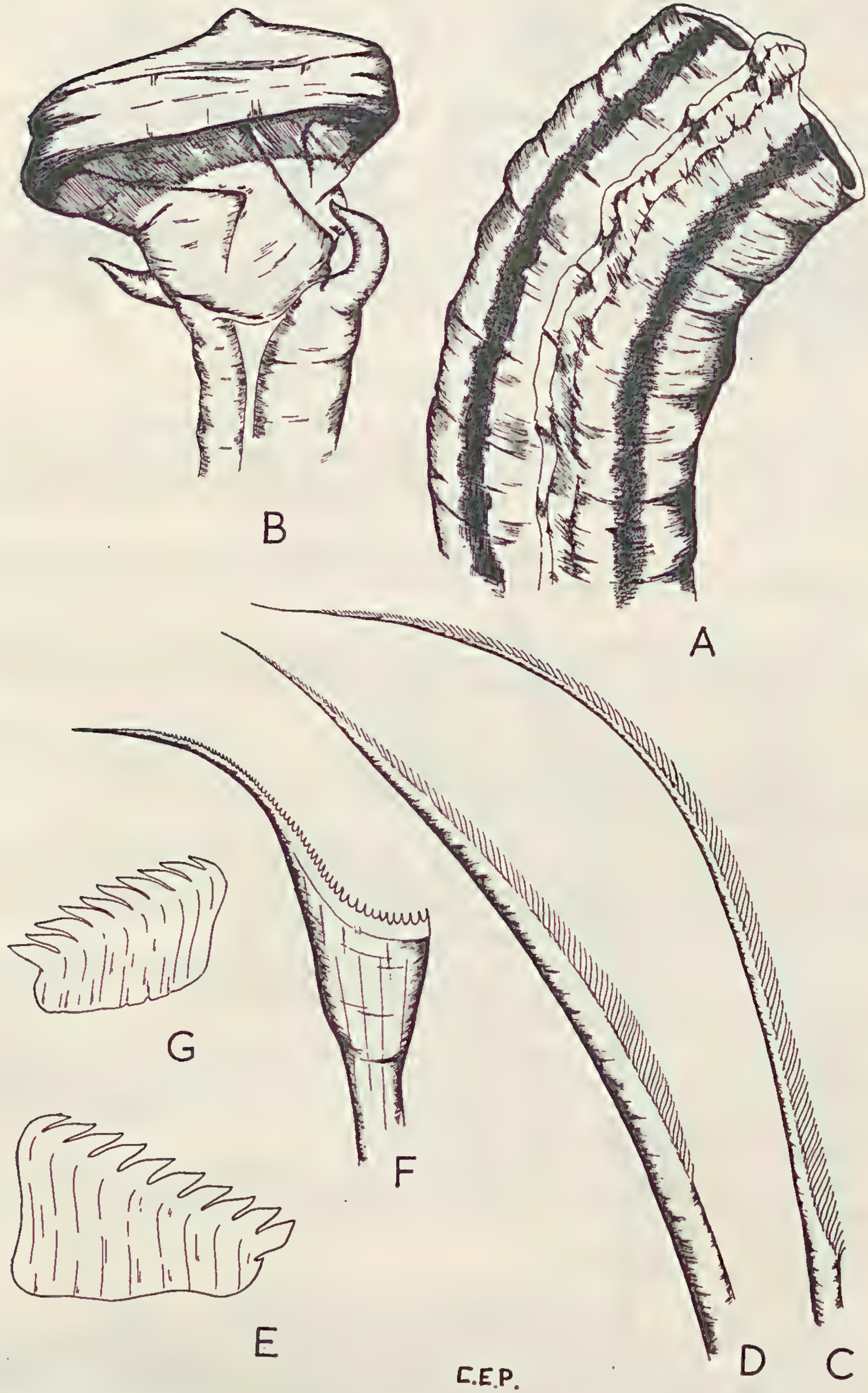


Fig. 13.—*Pomatoceros terrae-novae*: A, tube, x 13; B, operculum, x 30; C, collar seta, x 950; D, thoracic seta, x 950; E, thoracic uncinus, x 950; F, abdominal seta, x 950; G, abdominal uncinus, x 950.

Key to Species of Pomatostegus

1. Operculum with numerous discs on a central column ...... *P. stellatus.*
2. Operculum variable, flat or conical .... *P. polytrema.*

Pomatostegus stellatus (Abildgaard) 1789

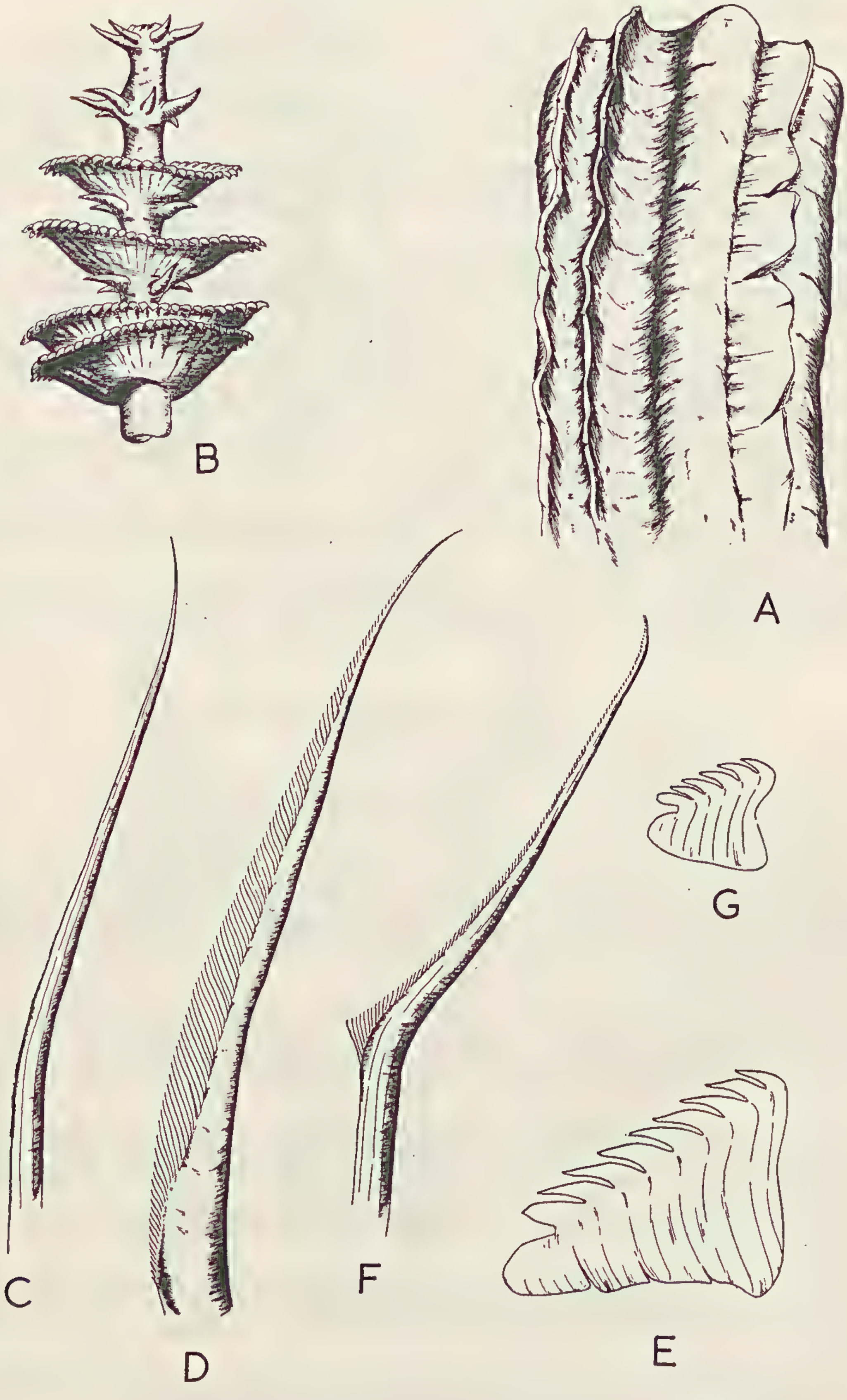


Fig. 14.—*Pomatostegus stellatus*: A, tube, x 13; B, operculum, x 12; C, collar seta, x 950; D, thoracic seta, x 950; E, thoracic uncinus, x 950; F, abdominal seta, x 950; G, abdominal uncinus, x 950.

Terebella stellatus Abildgaard, 1789.

Pomatostegus stellatus Pixell, 1913, p. 79; Fauvel, 1932, p. 246 (for synonym); Okuda, 1937, p. 309; Mesnil and Fauvel, 1939, p. 34.

Pomatostegus actinoceros Augener, 1914, p. 152.

Tubes.—Whitish, thick-walled, with one to three irregular longitudinal ridges and a tooth-like protection over the mouth. (Fig. 14A).

Branchiae.—Short, and terminating in a short naked filament, spirally arranged with between 26 and 34 filamentous pairs; pedicle broad and winged, the wings tending to form a continuous band for the whole length of the pedicle.

Operculum.—With two to five serrated horny discs, borne on a central column; beneath each disc is a star-like circle of projecting spines; at upper end a circle or circles of spines sometimes take the place of discs (Fig. 14B).

Collar.—Entire, well-developed, and appearing to cover and protect branchiae when in tube; collar unites with the thoracic membrane, which overlaps on ventral mid-line; setae of two types—(1) simple and faintly striated, (2) bayonet-like with a finely striated border and with a slight projection towards the base of the blade (Fig. 14C).

Thorax.—Seven setigerous segments; remaining six segments with setae of two types—(1) simple winged setae (Fig. 14D), (2) sickle-shaped (*Salmacina*) setae; winged setae in majority; *Salmacina* setae usually lose their characteristic shape in preservative; uncini with a single large terminal tooth and from nine to thirteen teeth (Fig. 14E).

Abdomen.—Varying number of segments; setae four per segment, are sickle-shaped and faintly serrated (Fig. 14F); uncini similar to those of thorax, but smaller and with fewer teeth (usually about six to eight) (Fig. 14G).

Discussion.—The material from Thursday Island, Queensland, was obtained from a "spat catcher" set to catch oyster spat. That from the Solomon Islands was removed from the shell of the hammer oyster *Malleus vulgaris.*

Material examined in Queensland (Thursday Island); Solomon Islands (Bougainville).

Distribution.—Western Australia (Shark Bay, Augener 1914); Red Sea, India, East Indies, Palau, West Indies, Atlantic Ocean.

Pomatostegus polytrema (Philippi) 1844

(Figs. 15 and 16)

Vermilia polytrema Philippi, 1844, p. 194, Pl. VI, Fig. N.

Pomatostegus polytrema Saint-Joseph, 1906, p. 252, Pl. V, Fig. 118-119; Fauvel, 1927, p. 369, Fig. 127, l-u.

Tube.—Pinkish to bluish-mauve, especially sides, but interior distinctly bluish; somewhat triangular in shape, and irregularly coiled; a single broad keel runs the whole length of dorsal surface and hangs over opening of tube in a tooth-like projection; two parallel rows of minute holes or pores appear along sides, one row just below keel, the other just above basal attachment (Fig. 16A); the clarity and size of pores varies considerably, as does the clarity of the ridges between them.

Branchiae.—24 pairs, with naked terminal filament; colour variable, but lower half usually yellowish-white and upper a straw colour; upper half is banded with five to six (usually five) dark brown splashes of colour on each side of mid-line; pedicle winged, arising from left branchial tuft; wings may be smooth (Figs. 15 A, B) or cut like a saw (Fig. 15C).

Operculum.—A flattish calcareous plate with narrow chitinous border; towards pedicle, on surface of plate, is usually seen a small flattish knob, never developing into spines or projections (Fig. 15A). Figs. 5B and 15C show some of the variations of the operculum.

Collar.—Tri-lobed, a large ventral and two small lateral; laterals fold back behind the ventral, giving the appearance of two upright projections; setae simple, usually 17 in number (Fig. 16B).

Thorax.—Thoracic membrane joining collar membrane and extending ventrally to cover thoracic region; seven setigerous segments; remaining six segments with stout limbate setae (Fig. 16C); uncini with 10-12 teeth, the most anterior somewhat larger and gouged (Fig. 16D).

Abdomen.—Setae trumpet-shaped, with a long terminal point (Fig. 16E); uncini similar to those of thorax, but smaller and with nine to 10 teeth (Fig. 16F).

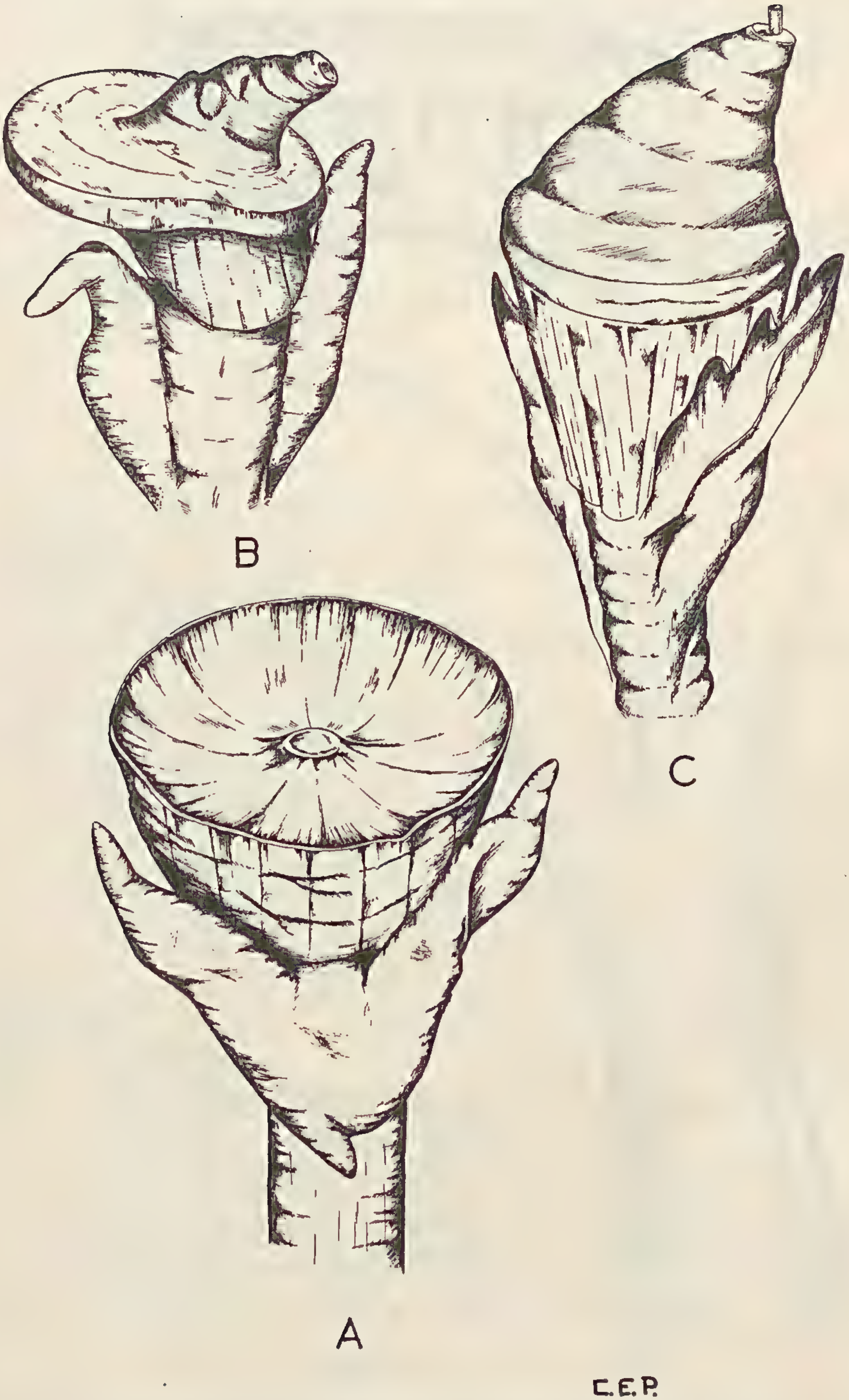


Fig. 15.—*Pomatostegus polytrema*: A, B, C, various forms of opercula, x 15.

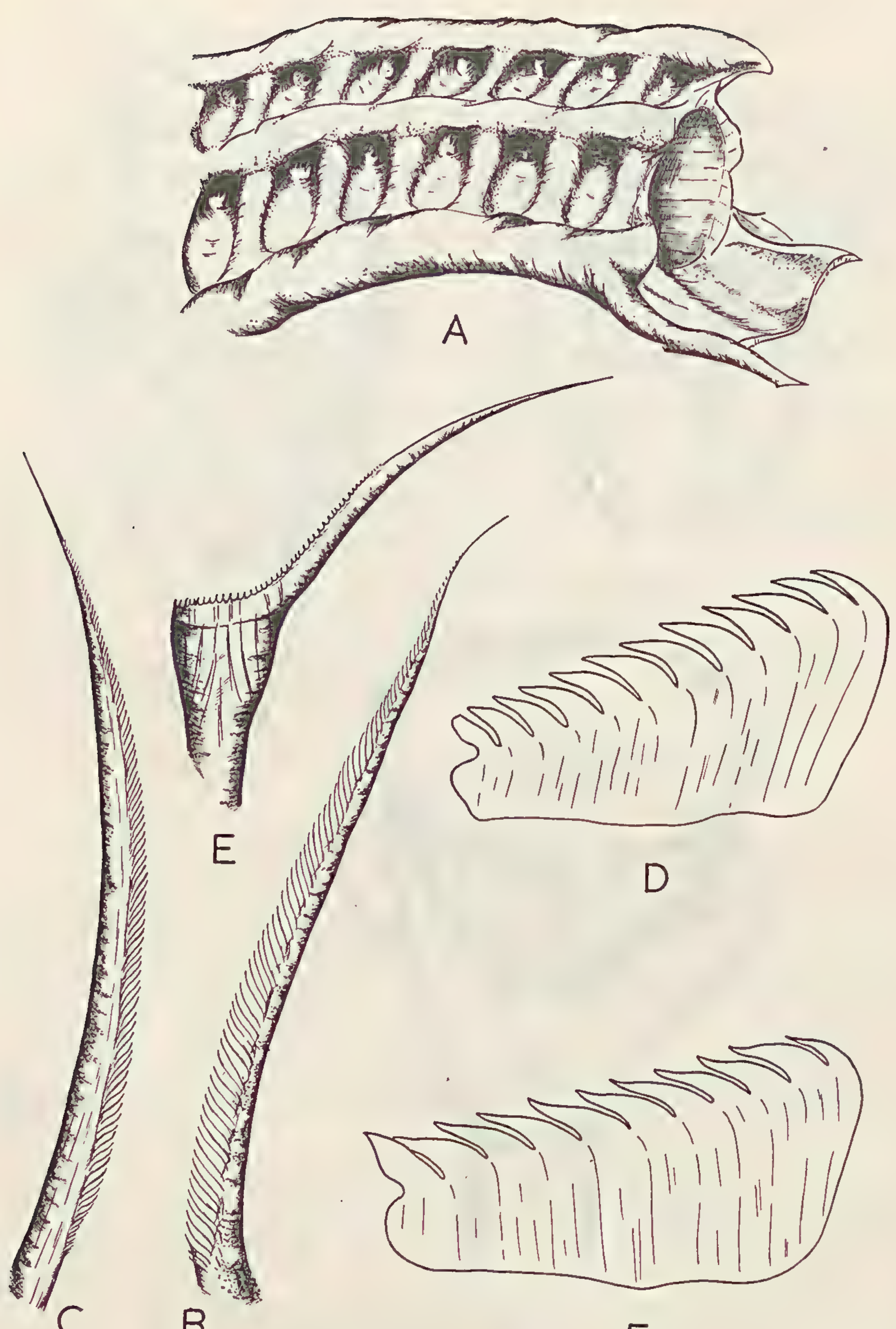


Fig. 16.—*Pomatostegus polytrema*: A, tube, x 7; B, collar seta, x 475; C, thoracic seta, x 475; D, thoracic uncinus, x 950; E, abdominal seta, x 475; F, abdominal uncinus, x 950.

Discussion.—This is the first record of this species from Australia. It has been collected at all times of the year, on stones and other submerged surfaces, both between and below tide levels. Its characteristic tube permits immediate and certain identification.

Material examined in New South Wales (Port Jackson; Kurnell, Botany Bay; Port Hacking; Tollgate Islands, Bateman's Bay); Victoria (Wilson's Promontory).

Distribution.—Mediterranean area.

Genus **Spirobranchus** Blainville, 1817

Operculum with calcareous plate, usually bearing a group of branched spines; pedicle winged; collar setae of two kinds—(1) simple, (2) bayonet-like and covered with fine hair-like processes; abdominal setae trumpet-shaped; uncini with numerous teeth, the most anterior one being larger and gouged out; uncinigerous tori of the two sides widely separated ventrally in front and gradually approaching one another towards the end of the thorax, thus leaving a triangular depression.

Spirobranchus giganteus (Pallas), 1766
(Fig. 17)

Serpula gigantea Pallas, 1766.

Cymospira gigantea Blainville, 1817.

Spirobranchus giganteus Mörch, 1863; Pixell, 1913, p. 80; Fauvel, 1932, p. 244 (for synonymy); Mesnil and Fauvel, 1939, p. 33.

Spirobranchus semperi Augener, 1914, p. 148 (for synonymy).

Pomatoceros elaphus Haswell, 1884, p. 663.

Tube.—Reddish-pink, with a definite blue-tinge inside; quite characteristic, strong, and somewhat triangular in section, with a marked serrated dorsal ridge and a tooth-like projection over the mouth of the tube (Fig. 17A).

Branchiae.—Variable in colour from a deep indigo-blue through burgundy to bright orange; others have a combination of these colours, with irregular coloured stripes; arranged spirally, number of whorls increasing with size and length of worm; specimens from tropical areas (Heron Island) tend to have five or six spirals on each side, while the specimens from the Sydney area have one or one-and-a-half spirals a side; pedicle broad and winged, the wings sometimes showing a fringed edge; pedicle usually bluish-green and arising from left side.

Operculum.—Variable, usually with a circular, calcareous basic plate which may be flat, concave or convex; plate carries on its superior surface a group of branched spines, which frequently have numerous short, branched, brittle secondary spines (Fig. 17B).

Collar.—Well-developed and brightly coloured; tri-lobed, with two lateral and a single large ventral lobe, usually notched at centre; shape variable, ventral lobe sometimes being badly shrunken, at other times folded back on itself, giving appearance of two triangular lappets; setae of two types—(1) simple (Fig. 17C), (2) bayonet-like, with numerous hair-like processes on its basic portion and a definite projection just above its junction with its main shank (Fig. 17D).

Thorax.—Seven setigerous segments; the six remaining segments with simple winged setae (Fig. 17E); uncini large, with up to 25 teeth, of which most anterior is stouter and hollowed out at end, giving it a gouged out appearance (Fig. 17F).

Abdomen.—Segments variable in number, with finely toothed geniculate setae (Fig. 17G); uncini similar to those of thorax, but slightly bigger (Fig. 17H).

Discussion.—Specimens collected at the Biological Laboratory of the Great Barrier Reef Committee, on Heron Island, had larger uncini and setae than the local Sydney forms. The tubes were nearly always surrounded with living coral, their branchiae making a very noticeable contrast in colour to the usual dull yellowish-green of the coral. Colours were very variable, some being immediately alcohol-soluble, others being much more resistant.

Material examined in Queensland (Thursday Island, Heron Island, Moreton Bay); New South Wales (Port Stephens, Norah Head, Port Jackson, Port Hacking).

Distribution.—Queensland (Low Isles, Monro 1931b); Western Australia (Shark Bay, Augener 1914); Indo-Pacific area, Persian Gulf, Natal.

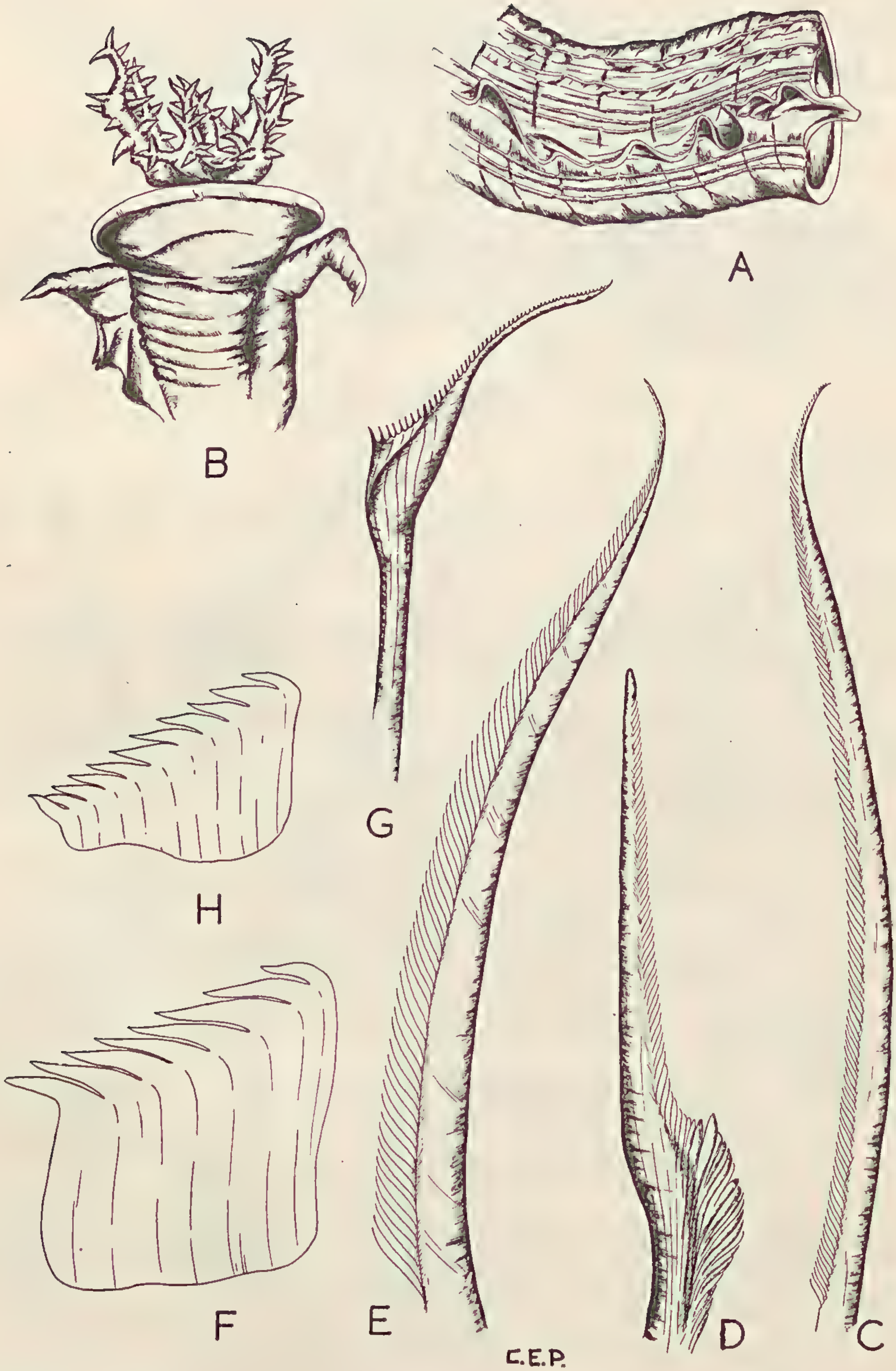


Fig. 17.—*Spirobranchus giganteus*: A, tube, x 8; B, operculum, x 14; C, D, collar setae, x 950; E, thoracic seta, x 950; F, thoracic uncinus, x 950; G, abdominal seta, x 950; H, abdominal uncinus, x 950.

Genus **Pomatoleios** Pixell, 1913

Collar setae and eye spots absent; uncini with fairly numerous teeth, the most anterior being larger and gouged underneath; abdominal setae trumpet-shaped, with one side produced into a long spine; operculum flat, with winged pedicle; tube with a flap over entrance.

Pomatoleios kraussii (Baird), 1864

Placostegus cariniferus var. kraussii Baird, 1864.

Pomatoleios crosslandi Pixell, 1913.

Pomatoleios kraussii Day, 1955, p. 449.

Material of this genus has not been examined, but it has been recorded from various points on the Queensland coast by Endean, Kenny and Stephenson (1956). It was recorded as *P. crosslandi,* but this species is synonymous with *Pomatoleios kraussii.*

Genus **Ditrupa** Berkeley, 1832

Operculum an inverted cone with a horny plate, usually striated, carried on a smooth pedicle; collar present, collar setae absent; uncini with numerous teeth, the most anterior one being larger, stouter and gouged; thoracic setae of two kinds—(1) simple capillary, (2) winged; abdominal setae simple capillary; tube calcareous, free-living, open at both ends and tusk-shaped, somewhat like the mollusc *Dentalium.*

Key to Species of Ditrupa

1. Tube tusk-shaped, no shoulder before mouth opening .... *D. australis*
   Tube tusk-shaped, pronounced shoulders before mouth opening 2

2. Mouth with pronounced lip, shoulders with curved slope .... *D. amphora*
   Mouth without pronounced lip, shoulders with straight slope .... *D. laeve*

Ditrupa australis Bretnall, 1921

(Fig. 18A)

Ditrupa australis Bretnall, 1921, p. 156, Fig 2.

Tube.—Whitish or grey, circular in section and tapering to a small opening at anterior orifice; outer surface smooth, slightly curved; length variable, typical specimen being 12 mm in length and 1.25 mm in diameter at the mouth, which is the widest part.

Discussion.—Specimens of this species have been obtained in dredgings on muddy bottoms at depths of from one to 10 fm. No trace of the worms have been found. In spite of a search, no trace can be found of the type.

Material examined in Queensland (Cairns to Endeavour Reef, Burkett Reef); New South Wales (Rose Bay, Double Bay, Green Point, all in Port Jackson; Gunnamatta Bay, Port Hacking).

Ditrupa laeve (Brazier), 1878

(Figs. 18B and 18C)

Dentalium laeve Brazier, 1878, p. 59.

Cadulus laevis Hedley, 1900, p. 499, Pl. xxvi, Fig. 8-10.

Ditrupa brazieri Bretnall, 1921, p. 156, Fig. 1.

Tube.—Whitish, circular in section, tapering to a narrow anterior orifice. The specimen examined was 7 mm in length and 0.75 mm in diameter at the widest part. At a distance of 0.5 mm from the mouth the sides sloped inwards, as in the sides of a cone, to form a mouth only 0.25 mm in diameter. There was no trace of the worm, which has never been found.

Discussion.—This species was originally described by Brazier in 1878 as a mollusc, *Dentalium laeve,* but this name had already been given to Schlotheimm's *Dentalium laevis* (1820). Further examination by a later worker, Bretnall (1921), proved that Brazier's species was a polychaete belonging to the genus *Ditrupa.* In spite of a careful search by several people, no trace of Brazier's material can be found.

Material examined.—Dredged by F.R.V. "Warreen" on 26th November, 1948, at Station 229W/48 (23°.02′S and 113°33′E), in 53 fm; bottom sand and muddy clay; sample obtained from a cone dredge, stored dry.

Ditrupa amphora sp. nov.

(Fig. 18D).

Tube.—Chalky white; outer surface smooth and porcelain-like; circular in section; posterior end shaped very like the top of a Greek amphora, having gently curving sides and a pronounced rim around the lip of the tube, anterior end terminating in a narrow orifice; overall length 8.0 mm, diameter at the widest part 0.75 mm, mouth 0.5 mm in diameter.

Types.—Holotype in Australian Museum, Sydney (Cat. W.3639).

Type locality.—Dredged by F.R.V. "Warreen" on 18th November, 1948, at Station 218/W (23°25'S and 113°13'E), in 78 fm; bottom coral sand and coral fragments; sample obtained in a cone dredge.

Discussion.—This species differs from the other two species of the genus quite considerably, but is closest to *D. laeve* in general shape and colour. The chief difference lies in the shape of the lip of the tube and the slope of the shoulders. The lip of *D. laeve* is sharp and clear while that of *D. amphora* has a pronounced rim. The shoulders of *D. laeve* have a sharp straight slope to the edge of the mouth, but *D. amphora* has a well defined curve, exactly like a Greek amphora. As in the two preceding species, the tubes examined lacked animals.

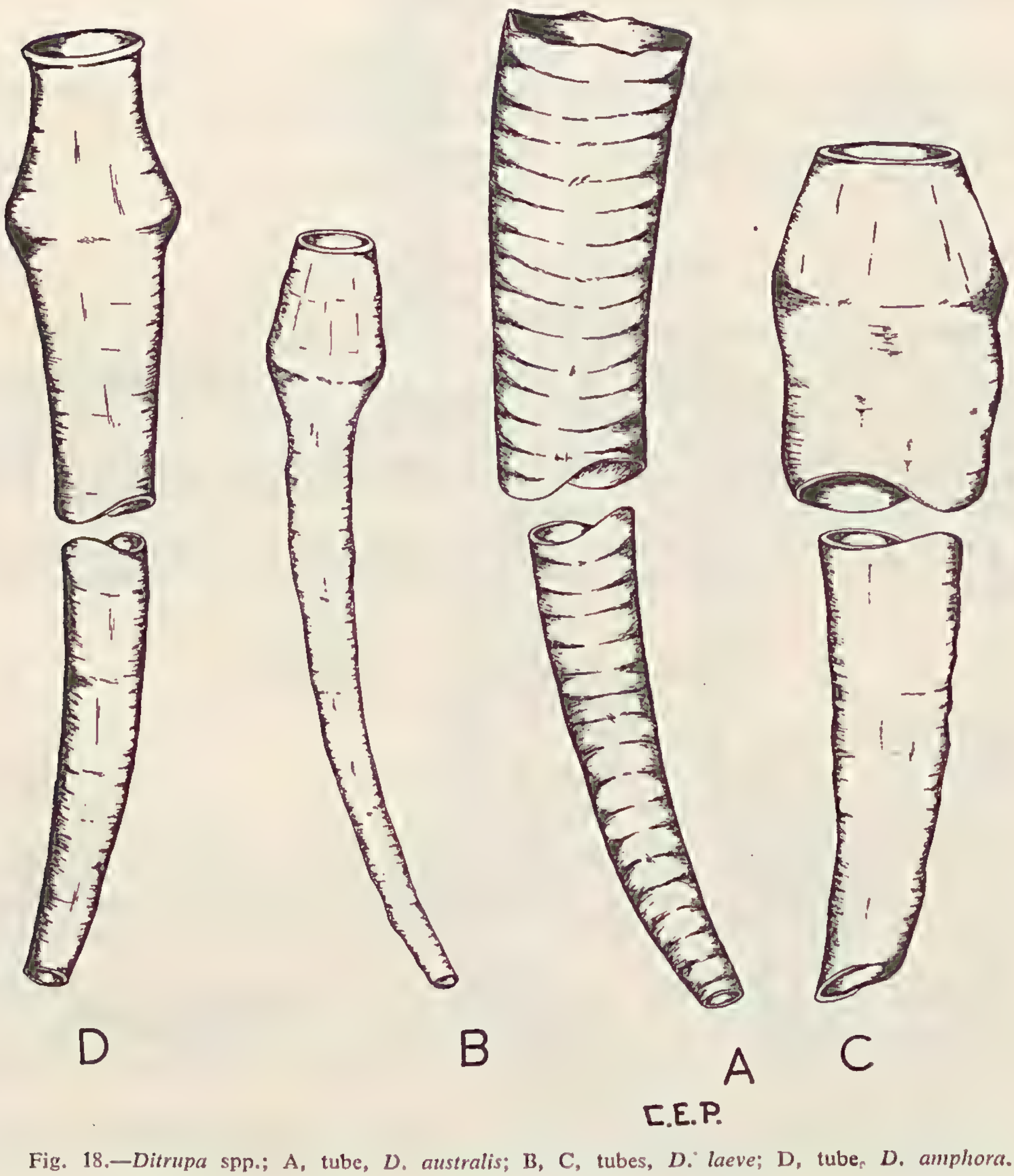


Fig. 18.—*Ditrupa* spp.; A, tube, *D. australis*; B, C, tubes, *D. laeve*; D, tube, *D. amphora*.

Genus **Salmacina** Claparede, 1868

Operculum absent; eight branchial filaments, with spatulate enlargements on their terminal ends; tubes calcareous, colonial and very fine, forming an intricate coral-like mass; uncini with numerous fine teeth, forming several rows when in front view; collar and thoracic membrane well-developed; eye spots present; hermaphrodite.

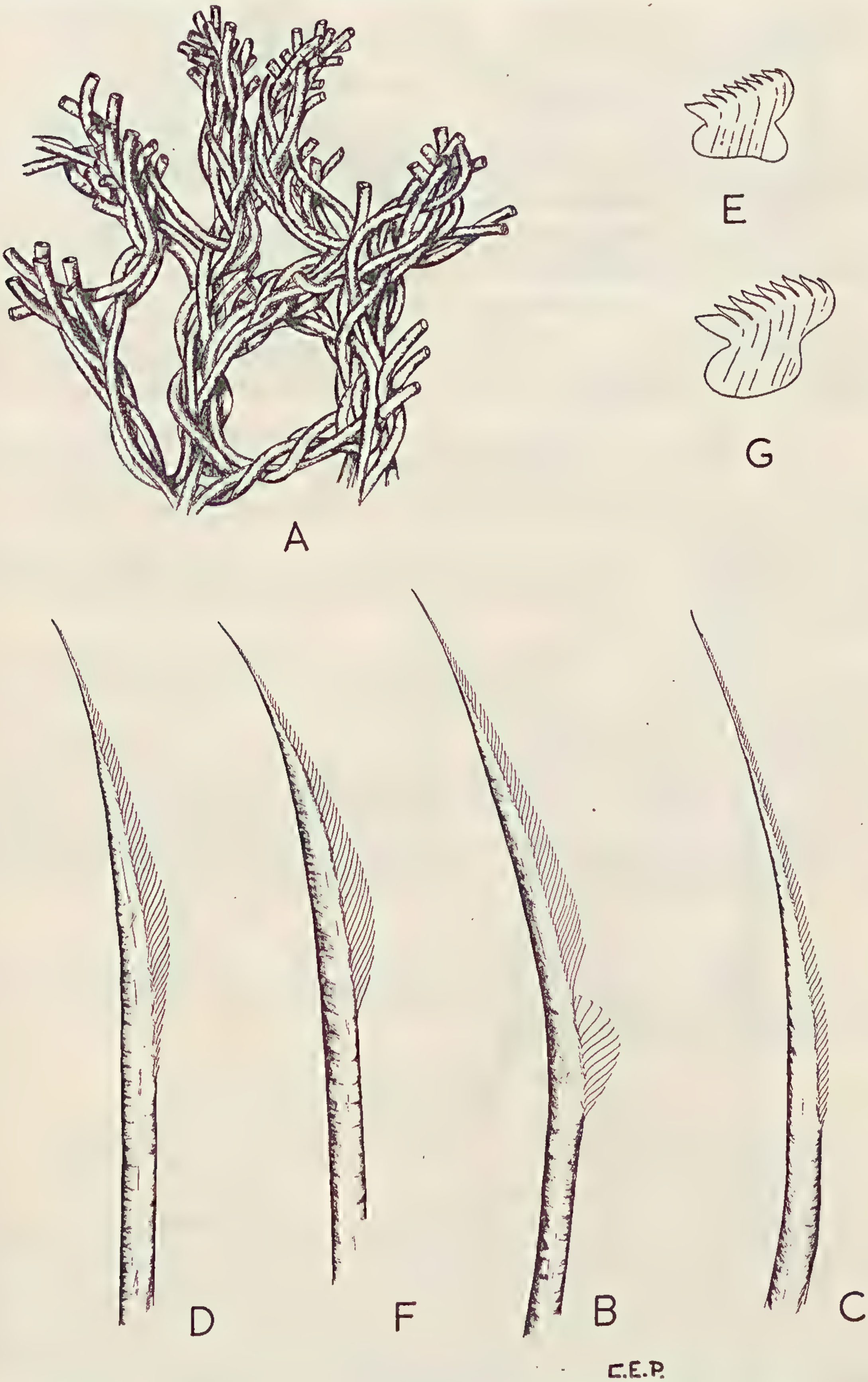


Fig. 19.—*Salmacina dysteri*: A, tube, x 5; B, C, collar setae, x 950; D, thoracic seta, x 950; E, thoracic uncinus, x 950; F, abdominal seta, x 950; G, abdominal uncinus, x 950.

Salmacina dysteri (Huxley), 1855

(Fig. 19.)

Protula dysteri Huxley, 1855, p. 113.

Salmacina dysteri Augener, 1914, p. 160; Fauvel, 1917, p. 271; Fauvel, 1927, p. 377 (for synonymy); Monro, 1931*b*, p. 31.

Salmacina australis Haswell, 1884, p. 669; Dakin, Bennett and Pope, 1948, pp. 206 and 208.

Tubes.—White and fine, forming an entwining, connected compact mass (Fig. 19A); colonies covering an area of over a square foot have been recorded, and a piece of a large colony, dredged off Lakes Entrance. Victoria, measured 21.5 cm in height; a colony is formed by the budding-off of individuals from the original worm.

Branchiae.—Four white or colourless, on each side of a transverse mouth opening, terminal filament being spatulate in shape and having a row of glandular cells around the circumference; the projecting prostomium has two eye spots at the base.

Collar.—Has two lateral lobes and a single large ventral one; joins the thoracic membrane, which covers a varying number of thoracic segments; setae of two kinds—(1) simple limbate (Fig. 19C), (2) complex and more numerous (Fig. 19B); these latter are divided into two distinct parts, the upper terminal portion being finely toothed and having a fine tapering point, the lower portion having a pronounced enlargement which is strongly toothed.

Thorax.—Segments vary in number from five to nine (usually seven to nine); setae of two kinds—(1) simple limbate setae (Fig. 19D), (2) those which are characteristic of the genus and are known as *Salmacina* setae; uncini small, with teeth in two rows (rarely three) when seen face-on, and small and fine, anterior being much stouter and longer, when seen in profile (Fig. 19C).

Abdomen.—Setae geniculate, finely toothed (Fig. 19F); uncini similar to those of thorax, but larger (Fig. 19G); there is an achaetous area between thorax and abdomen; body colour variable from red-orange through pink to white; the average size from 1 mm to 3 mm, the majority being 2 mm.

Discussion.—This very common Serpulid has been recorded from many parts of Australia by shore ecologists. It occurs from Thursday Island south, and west to Shark Bay (Western Australia). It is frequently found on ships and fouling test plates, and is of significance as a fouling organism.

Material examined in Queensland (Thursday Island, Heron Island, Moreton Bay); New South Wales (Angowrie, Norah Head, Long Reef, Port Jackson, Port Hacking, Wollongong, Jervis Bay, Eden); Victoria (Lakes Entrance, Portland, Apollo Bay, Mallacoota); South Australia (St. Vincent's Gulf, Spencer Gulf); Western Australia (Albany, Fremantle).

Distribution.—Queensland [Mair Island, Low Isles, (Monro 1931*b*)]; Victoria [Mallacoota-Portland, (Bennett and Pope 1953)]; Tasmania [off south-west Coast, (Monro 1939)]; Western Australia [Shark Bay, (Augener 1914)]; cosmopolitan.

Genus **Protula** Risso, 1826

Operculum absent; tube large and solitary; collar setae simple blades; thoracic setae simple winged blades and *Apomatus* type; abdominal setae either bayonet-like or sickle-shaped; terminal dorsal gland present.

Protula palliata (Willey), 1905

(Fig. 20)

Protulopsis palliata Willey, 1905, p. 316, Pl. VII, Figs. 183-185; Benham, 1916, p. 161, Pl. xlviii, Figs. 51-55.

Protula palliata Fauvel, 1911, p. 433.

Tube.—White, circular in section and fairly smooth, with only occasional faint, although sometimes well-marked, growth rings; solitary, fairly brittle, usually encrusted with sponges and bryozoa; growing edge white, easily seen on the under surface of rocks, etc. (Fig. 20A).

Branchiae.—Variable in number, usually about 25 pairs, arranged spirally, usually with $1\frac{1}{4}$ turns; naked terminal filaments yellowish-ochre in colour, with very conspicuous bands of brilliant orange-red; between these bands are irregular whitish-yellow blotches; as these blotches approach the tip they tend to become elongated; interbranchial membrane short, extending for about one fourth of the length of the branchiae (Fig. 20B).

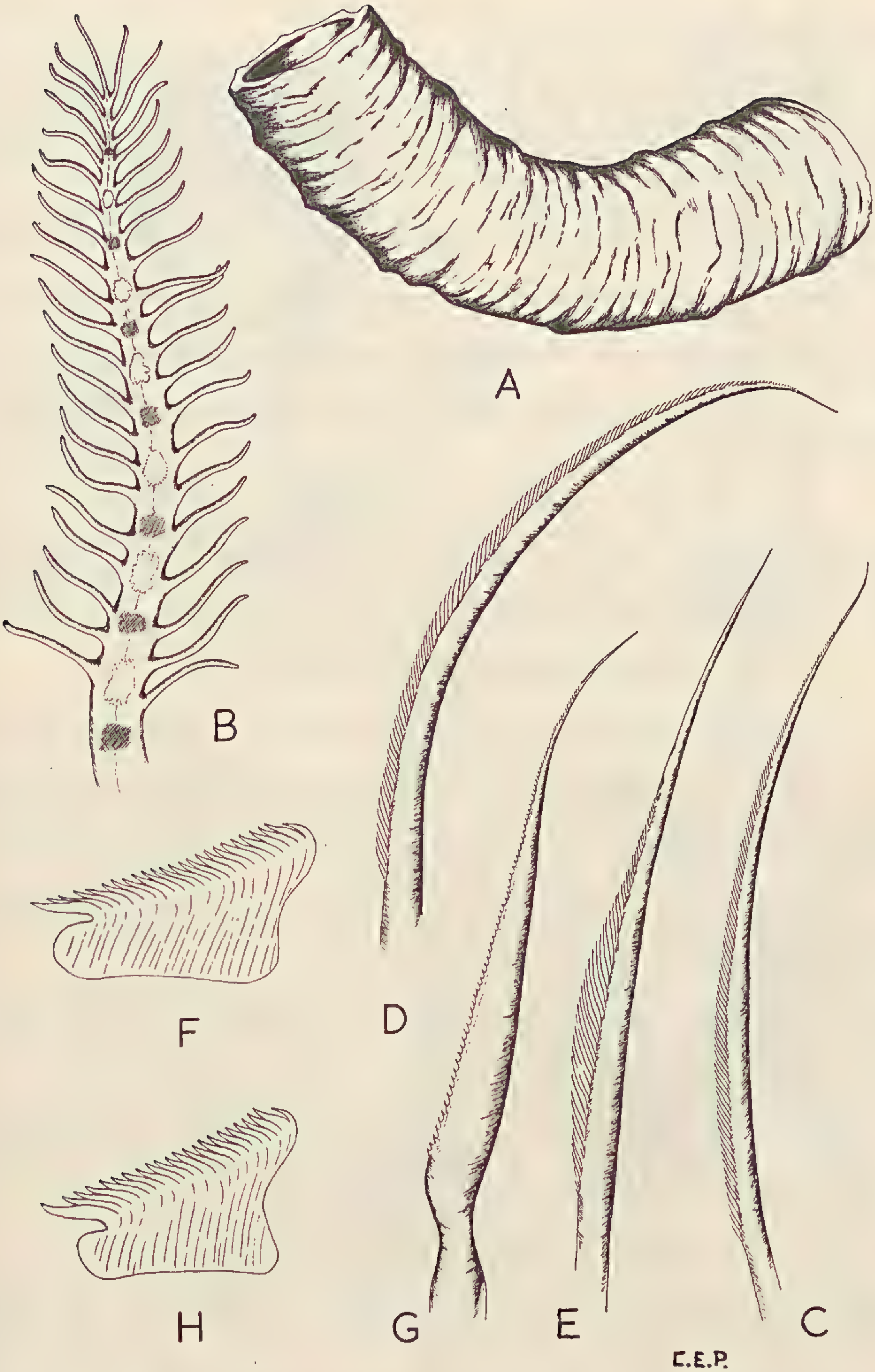


Fig. 20.—*Protula palliata*: A, tube, x 8; B, branchial filament; C, collar setae, x 475; D, E, thoracic setae, x 475; F, thoracic uncinus, x 950; G, abdominal setae, x 950; H, abdominal uncinus, x 950.

Collar.—Pale yellow ochre, well-developed, with three lobes of about same size; simple, limbate, capillary setae (Fig. 20C).

Thorax.—Thoracic membrane well-developed, forming a continuation of collar; this membrane, similar in colour to the collar, is large and undulating, tending to fold back on itself, especially along the edge; whole thorax well covered and protected; seven setigerous segments; remaining six segments with setae as those of collar (Fig. 20D), but in posterior three tufts there are setae of the *Apomatus* type (Fig. 20E); uncini with 22-25 teeth, the most anterior being elongated and narrow with a bifurcated tip (Fig. 20F).

Abdomen.—More than 100 segments; setae sickle-shaped and finely toothed (Fig. 20G); uncini similar to those of thorax, having 19-23 teeth, the most anterior being much longer (Fig. 20H).

Discussion.—This Serpulid is very common on the under surface of rocks around Sydney. Its conspicuous colour makes it easily distinguishable from any other species.

Material examined in New South Wales (Norah Head, Long Reef, Port Jackson, Port Hacking).

Distribution.—Western Australia [Shark Bay, Rottnest Island, (Augener 1914)]; Ceylon, Persian Gulf.

Genus **Josephella** Caullery and Mesnil, 1896

Operculum carried on the end of a branchial filament; collar well-developed; thoracic membrane rudimentary; collar setae capillary, limbate; five thoracic segments; uncini has two rows of fine teeth and two long projections arising from the anterior end; there is a long region between thorax and abdomen devoid of setae and uncini; the tube is calcareous and very fine, usually standing erect from its substrate; reproduces by budding.

Josephella marenzelleri Caullery and Mesnil, 1896

(Fig. 21)

Josephella marenzelleri Caullery and Mesnil, 1896, p. 482; Figs. 3-6; Fauvel, 1927, p. 380, Fig. 129 m-t.

Tube.—White, very fine and brittle, with faintly raised ridges; usually poorly attached to the substrata, and almost at once begin to grow away from the base at right angles; grow in clumps, each containing an individual worm, which may or may not be in the process of budding; it has not been possible to determine by what means these buds become separate from the parent and so form their own tubes.

Branchiae.—Two tufts, each containing three filaments, the pinnae being fringed with actively moving cilia; one pair of filaments is much shorter than the others; one of the longer filaments, which may be on either side, is modified to carry the operculum, the pinnae of the filament extending almost to base of operculum.

Operculum.—A small bell-like process, crowned with a cap surrounded by a circle of fine, upright spines, united by a fine membrane; the cap within the spines has a number of small upright knobs projecting from its surface (Fig. 21B). One specimen with two opercula, one on each side, has been examined.

Collar.—Well-developed, with three indistinct lobes, which are partly folded back on themselves; setae sickle-shaped, very small and fine, usually eight to a tuft (Fig. 21C).

Thorax.—Five setigerous segments; remaining four segments with setae of two types—(1) like those of collar (Fig. 21D), (2) sickle-shaped, without the fine striations (Fig. 21E); uncini very small, difficult to find, with a number of very fine teeth with two long, sweeping processes (Figs. 21 F, G); region between thorax and abdomen achaetous.

Abdomen.—Simple capillary setae which are narrow and non-libate (Fig. 21H); uncini similar to those of thorax, but somewhat thicker and shorter (Fig. 21I).

Discussion.—This is the first record of this species from Australia, and it is surprising that both should be from aquaria. Although a search has been made, no sign of the worms has been found outside these localities so far. It appears that the fairly still and protected waters of aquaria suit the worms.

Material examined in New South Wales [Taronga Zoological Park Aquarium (Port Jackson); C.S.I.R.O. Laboratory aquarium, Cronulla (Port Hacking)].

Distribution.—English Channel, Mediterranean Sea.

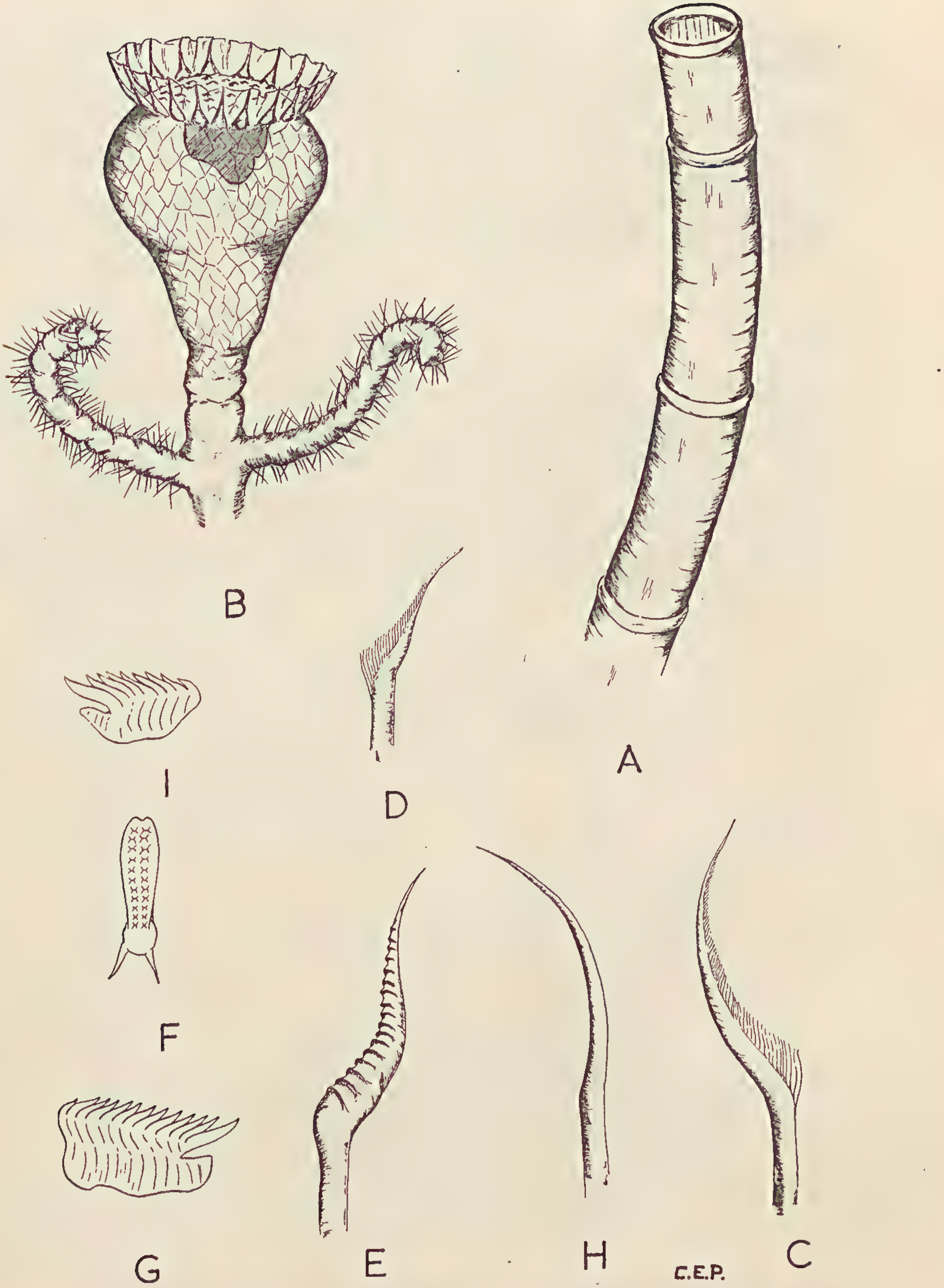


Fig. 21.—*Josephella marenzelleri*: A, tube, x 85; B, operculum, x 350; C, collar setae, x 1800; D, E, thoracic setae, x 1800; F, G, thoracic uncinus, x 1800; H, abdominal setae, x 1800; I, abdominal uncinus, x 1800.

Genus **Spirorbis** Daudin, 1800

Body asymetrical, less than five thoracic segments; operculum usually with a terminal calcareous plate; tube calcareous, coiled in either a dextral or sinistral spiral; incubation of the eggs either in the tube or the operculum.

Discussion.—This genus has a world-wide distribution, and is well represented in Australia. Bush (1904) described the empty tubes of *Spirorbis inversus* and *S. tridentatus* from Port Phillip, Victoria. *S. incisus* Mörch (1863) and *S. lammellosus* Lamarck (1818) have been recorded from King Island, Bass Strait. Lamarck (1818) also described *S. tricostalis* from King George Sound, Western Australia.

Numerous species have been collected in our fouling studies, mainly on the east coast of Australia. They include at least eight species from Gunnamatta Bay, Cronulla, New South Wales. They are a complex group, and have not been included in this paper because it is hoped to make this genus the subject of a separate contribution.

Acknowledgments

I wish to acknowledge all who have helped in the collection of the material described in this paper. I am indebted to the officers and staff of the Marine Laboratory, C.S.I.R.O. Division of Fisheries and Oceanography, Cronulla, New South Wales, for making facilities available and for other help. I am particularly indebted to Mr. C. Purday, who is responsible for the illustrations, and to Mr. R. Breach, who prepared the map.

I also wish to thank Mr. N. Tebble, of the British Museum (Natural History), and Dr. Olga Hartman, of the University of Southern California, U.S.A., for assistance with some of the identifications.

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THE PELORIDIIDAE OF LORD HOWE ISLAND

(Homoptera, Coleorrhyncha)

By J. W. Evans

Australian Museum

(Figures 1–5)

(Manuscript received 1.6.59)

For a considerable time it has been known that a representative of the archaic Homopterous family, the Peloridiidae, occurred on Lord Howe Island since a single nymph has been recorded from there (Bergroth, 1924). This had been collected by A. M. Lea.

Although during the intervening years several entomologists have visited the island, so far as is known no additional specimens have been collected. This is not surprising, as the insects are seldom found unless specially sought.

Because of their particular interest and because of their significance from the point of view of zoogeography, a visit was paid to the island during March, 1959, specially to search for these insects.

Lord Howe Island, which has a total area of approximately 5 square miles and is 7 miles long, is situated in the south-west Pacific, 300 miles east of Port Macquarie on the Australian coast. Port Macquarie is 100 miles north of Sydney. There are several islets adjacent to the island, one group in particular, the Admiralty Islands, being well known as the breeding place of numerous sea birds. About 18 miles to the south of Lord Howe Island is a remarkable pinnacle-shaped rock, 1,816 ft. in height, known as Ball's Pyramid.

The island is approximately crescentic in shape, the apices of the crescent being linked by a coral reef which encloses a shallow lagoon. This is the most southerly occurrence of reef coral in the world.

There are three groups of basaltic hills, linked together by sandy lowlands. The group at the southern end of the island consists of two precipitous mountains which rise to a height of 2,840 ft. (Mt. Gower) and 2,504 ft. (Mt. Lidgbird). The two other groups consist of hills ranging between 400 and 700 feet in height.

As is well known, the Peloridiidae occur only in moss which is permanently wet, and as the only place on the island where moss is known to occur in such a condition is on the top of Mt. Gower the search was narrowed to a restricted area.

The top of Mt. Lidgbird, like that of Mt. Gower, is frequently concealed by cloud and hence might be supposed capable of supporting vegetation with high moisture requirements, but while the summit of Mt. Gower consists of an undulating plateau several acres in extent, that of Mt. Lidgbird is a narrow crest.

In order to ascend Mt. Gower not only is fine weather necessary but also the services of a guide, as there is no readily recognisable track. Moreover, without an experienced guide it would be difficult to find one's way to the top in a morning's climb, since much of the mountain is precipitous.

Three attempts were made at an ascent, but the two first had to be abandoned because of bad weather. The third, which was made on the last day spent on the island, was successful.

The vegetation on the top of Mt. Gower, which is considerably different from that growing on the rest of the island, includes tree ferns, two of the four species of endemic palms, *Dracophyllum fitzgeraldi*, and various small trees and shrubs. Oliver (1916) has described how " almost every available space, whether on standing or prostrate stems and branches of trees, tree ferns and palms, appears to be thickly covered with ferns, mosses and lichens ".

Three hours were spent on the top of Mt. Gower, and a search of moss made by my wife, our guide, Mr. R. Payten, and myself yielded a total of 24 adult Peloridiids and seven nymphs.

These, on examination, proved to represent what appear to be two species which, though having affinities with *Hemiodoecus leai* China and *H. veitchi* Hacker, are nevertheless sufficiently distinctive to merit the creation of a new genus for their reception.

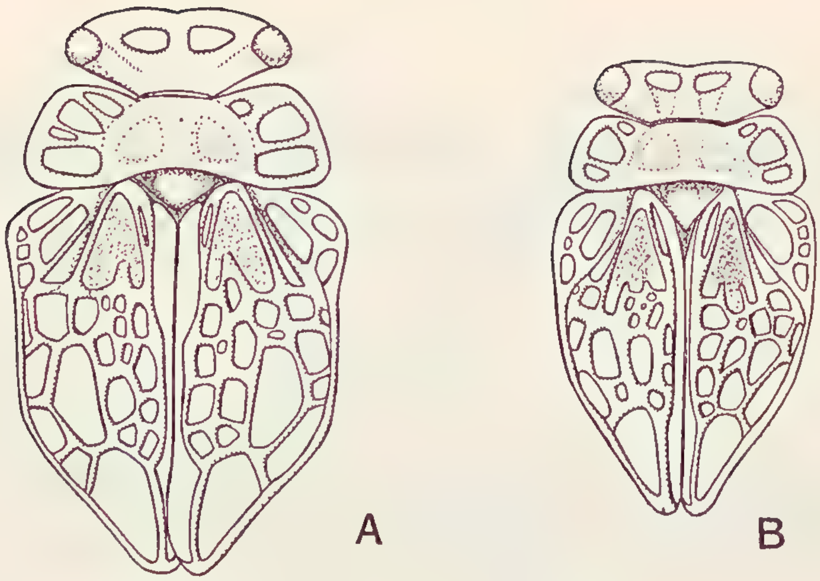

Figure 1.—A. *Howeria kingsmilli.* B. *H. payteni.*

Howeria gen. nov.

The anterior margin of the head is slightly medially emarginate and either slightly rounded anterior to the eyes or else transverse. Small paired cephalic areoleae are present, which in length are approximately equal to one-third or one-quarter of the total length of the crown. The eyes are not globosely prominent, but form part of the curve of the head. The pronotum is slightly elevated medially, and laterally depressed. The prothoracic paranota are quadrilateral in shape and have the anterior and posterior corners rounded. Each has from two to four wide veins, any one of which may be branched apically. The tegmina, which are convex, may have the costal margin sinuate immediately behind the sub-costal expansion, or straight. The sub-costal expansion, which lies at a lower level than the rest of the tegmen, has a single large or two smaller cells posterior to Sc (for an interpretation of the venation of Peloridiids, see Evans, 1939) and three or more smaller cells between Sc and the costal margin.

The proximal part of the tegmen between M and the anal area is depressed, smooth and shiny, and the base of Cu1 is entirely obliterated. R lies along the costal margin of the tegmen, and the venation between M and the hind margin, except apically, is profusely reticulate. The margins of the cells, and sometimes also the cells themselves, are punctate.

Type species—Howeria kingsmilli sp.n.

Howeria spp are more closely related to certain species in the genus *Hemiodoecus* China than to species in any other genus of the Peloridiidae. In particular, they resemble *H. leai* China, the Type species, in the shape of the hind margin of the genital capsule, and *H. veitchi* in having R coinciding with the costal margin of the tegmen; thus the row of cells, which in most Peloridiids lie between the costal margin and R, are absent.

They differ from *Hemiodoecus* in having R and M distinct basally and not fused into a single vein; in the obliteration of the base of Cu1, and in the reticulate condition of the venation in the convex median part of the tegmen.

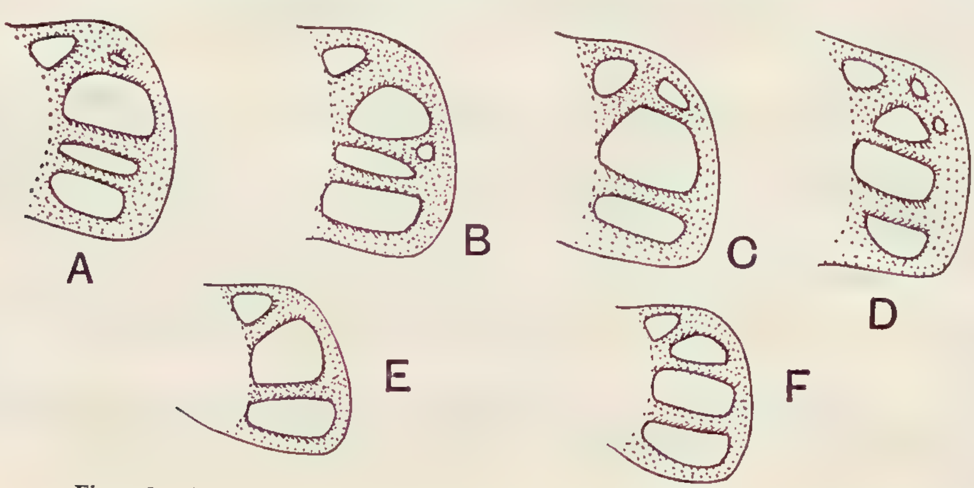

Figure 2.—A—D. Pronotal paranota of *Howeria kingsmilli.* E, F. Those of *H. payteni.*

Howeria kingsmilli sp.n.

Dimensions: ♂ length, 3 mm; width of head, 1 mm; width across paranota, 1·6 mm; width across tegmina at their widest part, 1·7 mm. Corresponding measurements of ♀, 3·1, 1·15, 1·7, 1·8 mm.

Crown of head anterior to and between the areoleae, pale chestnut brown; posteriorly dark brown; eyes, dark reddish brown. Anterior margin of crown of head, slightly rounded in front of the eyes and slightly medially emarginate.

Prontum concolorous with the posterior part of the head, the lateral medial depressions and the posterior third of the paranota, darker in colour than the remainder. Lateral expansions with a variable number of veins, up to four in number, but usually with two only, of which one, on either or on both sides, may be apically branched. Tegmina extending laterally beyond the paranota; costal margins sinuate posterior to the sub-costal expansions, marked with a variable pattern of light and dark brown; the sub-costal expansions, the costal margins and the apices, usually paler than the greater part of the rest of the tegmina.

Male genitalia: Ventral posterior margin of genital capsule medially narrowly acute, with a pair of small lateral triangular processes. Harpogones bent inwards, apically narrowly spoon-shaped.

Female genitalia: First and second valvifers and valvulae as in Figures 5, A, B.

Holotype, sub-brachypterous ♂, and *Allotype* sub-brachypterous ♀, from Mt. Gower (2,800 ft.), Lord Howe Island; in the Australian Museum (Registered numbers K67934, K67935); two *Paratypes* in the British Museum. Described from a total of 9 ♂♂ and 8 ♀♀.

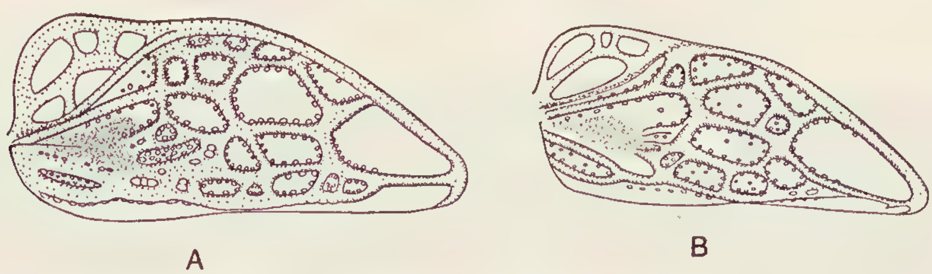

Figure 3.—A. Forewing of *Howeria kingsmilli*. B. That of *H. payteni*.

Howeria payteni sp.n.

Dimensions: ♂ length, 2·6 mm; width of head, ·9 mm; width across paranota, 1·35 mm; width across tegmina at their widest part, 1·35 mm. Corresponding measurements of ♀, 2·55—2·7 mm; ·85—·95 mm; 1·20—1·30 mm; 1·40—1·60 mm.

Differs from the Type species in its smaller size; in the smaller degree of variability of the venation of the pronotal paranota; in having the costal margin of the tegmen anteriorly straight and not sinuate; in having a greater development of punctures in the tegminal cells additional to the marginal ones, and in the generally darker coloration.

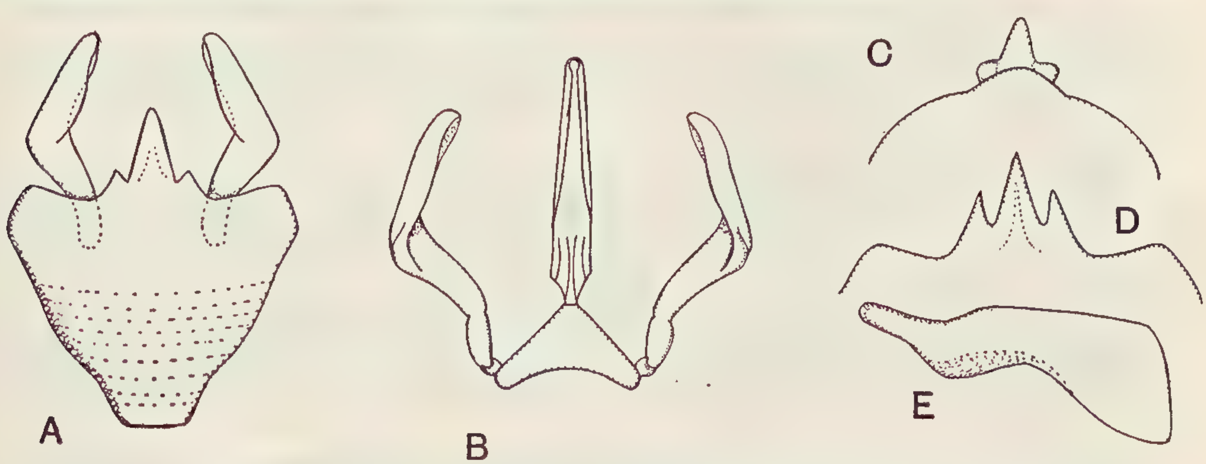

Figure 4.—A. Male genital capsule and harpogones of *Howeria kingsmilli* in ventral aspect. B. basal plate, harpogones and aedeagus of *H. kingsmilli*. C. hind margin of genital capsule of *Hemiodoecus veitchi*. D. hind margin of genital capsule of *H. leai*. E. harpogone of *H. leai*.

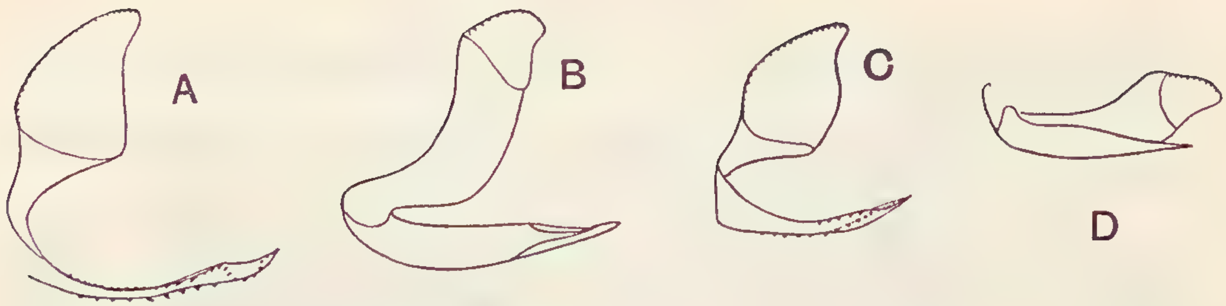

Figure 5.—A. First valvifer and valvula of *Howeria kingsmilli*. B. Second valvifer and valvula of *H. kingsmilli*. C. First valvifer and valvula of *H. payteni*. D. Second valvifer and valvula of *H. payteni*.

Female genitalia as in Figures 5, A, B. It is not possible at present to figure the male genitalia, since those of the two available specimens were lost, due to a mishap, in the course of preparation for examination.

Holotype, sub-brachypterous ♀, and *Allotype* sub-brachypterous ♂, from Mt. Gower (2,800 ft.), Lord Howe Island; in the Australian Museum; 1, ♀, (Registered numbers K67936, K67937). Paratype in the British Museum. Described from a total of 5 ♀♀ and 2 ♂♂.

DISCUSSION

The two species of Peloridiidae described above bring the total of the known species of this Family to fifteen. Of the previously described ones, two (*Peloridium hammoniorum* Breddin and *Peloridora kuscheli* China) occur in cool temperate South America; six (*Xenophyes cascus* Bergroth, *X. stewartensis* Woodward, *Oiophysa ablusa* Drake and Salmon, *O. fuscata* Drake and Salmon, *O. distincta* Woodward, *O. cumberi* Woodward) in New Zealand; and five (*Hemiodoecus leai* China, *H. veitchi* Hacker, *H. wilsoni* Evans, *H. fidelis* Evans and *H. donnae* Woodward) in Eastern Australia.

In deciding how best to place the Lord Howe Island specimens, two decisions needed to be taken. First, whether to regard them as representatives of two, or of a single, species, and second, whether to include them in the genus *Hemiodoecus* or to create a new genus for their reception.

Dimorphism is known to occur among the Peloridiidae, since more than one form of *Peloridium hammoniorum* is known. The differences between these forms, however, are not so much ones of size as in their state of wing development.

In the relict New Zealand ulopid genus *Myerslopia* Evans (Cicadellidae), two groups of individuals occur which differ principally from each other in overall size. These have been regarded as separate species, though it is not known whether this represents correctly their true status. (Evans, 1947.)

As the difference in size of the two forms of *Howeria* is constant and as it is accompanied by others of a structural nature, it was decided to recognise each form as representing a distinct species. The fact that they were collected together in an identical environment might be regarded as a reason for doubting whether they were specifically distinct, but, as in Tasmania *Hemiodoecus leai* and *H. fidelis* have been found in the same piece of moss, this fact would not seem to preclude species separation.

The problem of generic placement is equally difficult. China (1924) has suggested that the Lord Howe Island Peloridiid probably belonged to the genus *Hemiodoecus*. Doubtless his suggestion was based more on the geographical situation of the island than on its actual faunal and floral associations. It has already been mentioned that *Howeria* spp. show particular affinity with two species of *Hemiodoecus*, *H. leai* and *H. veitchi*. The ventral posterior margin of the genital capsule of *H. leai* (Figure 4, D) resembles that of *Howeria kingsmilli* (Figure, 4, A), although the harpogones of the former (Figure 4, E) are very different from those of the latter. The resemblance of *H. veitchi* to *H. kingsmilli* is associated with a venational and not with a genitalia character, and the hind ventral margin of the genital capsule of *H. veitchi* (Figure, 4, C) does not closely resemble that of *H. kingsmilli*.

Howeria spp. have also certain similarities with the South American Peloridiids, since, like these, they possess only a few cells in the pronotal paranota. They differ in this characteristic from all the New Zealand species and from certain of the Australian ones.

Because of the remarkable stability in form of the Peloridiidae, combined with their high degree of individual variability; because of the occurrence of the few readily apparent distinctive characters in various combinations in the different species, and because of the fact that the two Lord Howe Island species are considerably more closely related to each other than they are to any of the species in the genus *Hemiodoecus*, it was decided that, rather than include them in this existing genus, it was preferable to create a new one.

Although *Howeria* spp. show affinity with some *Hemiodoecus* spp. they are not closely related to all species in this genus.

Woodward (1956), in a discussion of the inter-relationship of Australian and New Zealand genera of the Peloridiidae, has pointed out that the species comprised in the genus *Hemiodoecus* can be separated into two species groups. In one, containing *H. leai*, *H. veitchi* and *H. wilsoni*, the pronotal paranota contain two or three cells and the harpogones in the male genitalia are simple. In the other, containing *H. fidelis* and *H. donnae*, the paranota contain numerous small cells and the harpogones are forked.

As *Howeria* spp. are undoubtedly more closely related to the species in the first group than are those in the latter to the species in the second group, it becomes necessary, in order properly to express interrelationships, to create a new genus to contain *Hemiodoecus fidelis* and *H. donnae*, and this is done below.

Hemiodoecellus gen.nov.

The anterior margin of the head is slightly rounded in front of the eyes, or transverse, and the cephalic areoleae are reticulate. The pronotal paranota are likewise reticulate and the venation is highly variable. The costal margin of the tegmen is anteriorly straight; R is separated from the costal margin by a row of regularly spaced cells and the remaining cells in the tegmen are marginally punctate.

In the male genitalia, the posterior ventral margin of the genital capsule has a single lobe-shaped median process and the harpogones are branched.

Type species—Hemiodoecus fidelis Evans.

Hemiodoecellus differs from all other genera of the Peloridiidae, of which the male genitalia have been illustrated, in having bifurcate harpogones. It resembles *Xenophyes* and *Oiophysa* in having the venation of the pronotal paranota reticulate, and in this respect differs from *Hemiodoecus*, *Peloridium*, *Peloridora* and *Howeria*.

In addition to the Type species, *Hemiodoecus donnae* Woodward is transferred to the genus *Hemiodoecellus*.

THE ZOOGEOGRAPHICAL SIGNIFICANCE OF THE OCCURRENCE OF PELORIDIIDS ON LORD HOWE ISLAND

The problem of the origin of the fauna and flora of Lord Howe Island has been discussed by many authors. In a recent paper entitled " Lord Howe Island, A Riddle of the Pacific " (1958), Paramanov has pointed out that the basic flora is quite unlike Australia's and that typical elements of the New Zealand flora are practically absent. Hindwood (1940), in an article on the birds of the island, mentions that the strongest association of the fauna and flora is with New Caledonia, and this fact has been noted by many previous authors.

The southern beech *Nothofagus*, with the distribution of which Peloridiids are associated in Chile, New Zealand, Tasmania and Australia, grows also in New Caledonia, and because of this the author visited this island in 1957 to search for Peloridiids. None was found, nor was an environment discovered which would be favourable for their existence. *Nothofagus* is absent from Lord Howe Island. Nevertheless, there are several elements in the island's fauna and flora with southern associations. Thus, remains of fossil extinct horned turtles belonging to the genus *Meiolania* are abundant. Elsewhere, they have been recorded from Walpole Island, near New Caledonia, Queensland and Patagonia. Paramanov states that these turtles were probably marine, but whether they were so or not is uncertain.

Among plants, *Sophora tetraptera* and *Lobelia anceps* have been recorded from Lord Howe Island, New Zealand and South America, and *Apium prostratum* from Norfolk Island, the Kermadecs, New Zealand, Tasmania, Australia, southern South America and South Africa. A plant belonging to a genus with an interesting discontinuous distribution is *Moraea robinsoniana*, which grows on Lord Howe Island, all other representatives of the genus being confined to Africa (Oliver, 1916).

The presence of Peloridiids on the island strengthens the supposition which has been advanced by many previous authors that it was formerly part of a larger land mass, since these insects are unlikely to be capable of transport by adventitious means.

Other Homoptera include a single cicada, *Psaltoda insularis* Ashton, which is an endemic species belonging to an Australian genus and has doubtless been derived from an adventitious immigrant.

There are also at least two species of cercopids, but these would seem to be closer to two of the three species occurring in New Zealand (*Ptyelus trimaculatus* (White) and *P. subvirescens* (White)) than to any Australian ones.

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A REVIEW OF THE AUSTRALIAN SPECIES OF CLUSIIDAE

(Diptera, Acalyptrata)

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(Figs. 1-36) (Manuscript Received 9.10.59)

SYNOPSIS

Characters for recognition of both adult and larval specimens of Clusiidae are given. A larva from Australia is described, and some characters of the puparium of one species are noted.

The morphology of the male terminalia is discussed in order to determine the homologies of the parts and to provide a sounder basis for classification. It is shown that those genera which have been sufficiently investigated can be distinguished from one another by characters of the male postabdomen.

The geographical origin of the Australian forms is discussed.

Keys to the genera of Clusiidae, to all described species of *Allometopon* and to the Australian species of other genera are provided. Two genera and 19 species are described as new.

INTRODUCTION

The species of the family Clusiidae, once called Heteroneuridae, are, in Australia as in other regions, difficult to collect in numbers. This is no doubt due to rarity (small population size) of many of the species and to extreme localization of others. The known larvae live in rotting wood and the adults inhabit forest country.

The only previously recorded Australian species are the two species of *Heteromeringia* described by Malloch (1926, 1930) on the basis of three specimens. The present work is based on more than 170 Australian specimens, but most of these were collected within a short distance of Sydney and in a few localities in Queensland. A few specimens from Western Australia and one from Tasmania have been examined, but no material from other States is available. The family is probably absent from the drier part of the continent.

Hennig (1958) considers that the family Clusiidae belongs to the group of families which includes the Helomyzidae and its allies. This position is tentatively accepted, though the long, divergent postverticals are a discordant character. The only other possible location seems to be in Hennig's superfamily Pallopteroidea.

The monograph on the Clusiidae by Melander and Argo (1924) may be consulted for references to earlier papers, generic synonymy and keys to and descriptions of the species then known.

RECOGNITION OF CLUSIIDAE

Adult Characters

Head with strong vibrissae; postvertical bristles divergent or absent; fronto-orbital bristles two to five; epistomal ridge between face and buccal region absent, the cuticle in this region soft and not sclerotized. Antenna porrect or almost so; second segment produced into a short, angular lobe on outer distal edge. Thorax with sternopleural, mesopleural and at least two pairs of dorsocentral bristles. Wings with subcosta, second basal cell and anal cell complete.

In distinguishing representatives of this family from other Acalyptrata, first check the venation. If it agrees with the above description check the vibrissae, antennae, face and postverticals. Only if all these characters are in agreement is the specimen a clusiid.

Larval Characters

The larvae of Clusiidae are very distinct from those of other acalyptrate families. The cephalopharyngeal armature is vestigial and unpigmented. The posterior end of the larva is not truncated, but bears two short, rigid processes on which the spiracles open. These characters, together with the fact that the only known habitats are in rotting wood and termite galleries, should make them easy to distinguish from other muscoid larvae.

The only clusiid larvae seen by the author are two specimens found in moist rotting wood in rain forest at Mount Wilson, Blue Mountains, New South Wales, on April 16, 1957. These were kept in captivity but did not survive to pupate, though one lived till September 20. The following notes and Figs. 12 and 13 have been prepared from these two specimens, which appear to be conspecific :—

Larva transparent, without pigment except on posterior stigmatic processes. General form cylindrical, slightly dorsoventrally compressed, somewhat tapered anteriorly, broader and more flattened posteriorly. No cephalopharyngeal armature visible in living larva. Striated ventral pads present on all segments except the first two, that on terminal segment small; the latter segment with numerous small sclerotized pits which, from observations on the living larvae, appear to be points of attachment of muscles to the cuticle. Anterior spiracles on small tubercles, each with about five openings. Posterior spiracles situated on the inner surface of paired, terminal, upwardly curved, undivided, yellowish-brown processes; each spiracle with three openings. No other processes or secondary annulations on larva. Length, 3·5 mm.

The only other knowledge of the immature stages of the Australian forms has been obtained from the puparia of the type series of *Heteromeringia norrisi* sp. nov. These have been mounted with the adults. As might be expected from the puparia of other flies, they are stouter than the larvae described above and not depressed. The presence of numerous transverse wrinkles is probably another character not present before pupation. The only visible taxonomic difference separating these from the larvae from Mount Wilson is in the unequally forked posterior processes (Fig. 7).

THE MALE TERMINALIA

Notes on Basic Morphology

Difficulties have been experienced in determining the homologies of the terminal organs in the males of higher Diptera. The detailed evidence supplied by Crampton (1942, 1944a) is so sound that, after due consideration, the author accepts all his conclusions concerning the identity of the sclerites in the postabdomen of Diptera. The interpretations of Hennig (many papers on Acalyptrata; bibliography in Steyskal, 1957), Zumpt and Heinz (1949, 1950) and Steyskal (1957) differ somewhat from those here accepted.

Steyskal follows Crampton in much of his terminology but, like Hennig, he considers that the dorsal sclerite preceding the hypopygium consists largely of the eighth tergite, with sclerites of the seventh segment forming a smaller part. In the Orthopyga (as defined by Aczél, 1954) it is generally the eighth sternite which is greatly developed, the eighth tergite being frequently a narrow transverse strip, and Crampton has traced the evolution of the acalyptrate terminalia from these forms by way of the Aschiza. He shows that the dorsal sclerite of the eighth segment in the Schizophora is the eighth sternite with which the seventh sternite is more or less fused.

As Hennig (1958) has recently vigorously attacked Crampton's theory, it is necessary to reconsider some points relating to circumversion and asymmetry.

In spite of the paucity of observations, it is reasonable to assume that all Cyclorrhapha have a hypopygium circumversum (Aczél, 1954; Hennig, 1958). Aczél has associated this character with the folding of the hypopygium forwards below the protandrium. My studies show that Aczél's assumption holds good for the Dolichopodidae, for in *Sciapus* the relative twisting of the hind gut and vas deferens is indicative of circumversion. His inclusion of the Dolichopodidae together with the Cyclorrhapha in the division Campylopyga therefore seems correct. Aczél's later conclusion (1955) that *Nothybus* has not a hypopygium circumversum on account of its symmetrical postabdomen is untenable (Hennig, 1958).

Hennig considers that the rotation of the postabdomen in the Cyclorrhapha has probably little to do with asymmetry. He further accuses Crampton of choosing only those forms which suit his theory and placing these unrelated forms together to form an evolutionary series. To some extent this criticism is true, for Crampton's derivation of the Calyptrata from the Helomyzidae, Clusiidae, or related forms, and his derivation of the Cordyluridae from the Micropezidae cannot be accepted. Nevertheless, there are so many cases of asymmetrically developed sternites in Cyclorrhapha that the condition almost certainly constitutes a basic character of this complex. Crampton might well have chosen quite different families of Schizophora to illustrate his point. Within the higher Cyclorrhapha (Syrphidae, Pipunculidae and Schizophora) the postabdominal sternites frequently form a spiral series in the same direction as the torsion of the hypopygium. In certain Coelopidae the sixth to ninth tergites form a similar spiral series. There can be no other logical conclusion than that this spiral displacement is brought about through the rotation of the hypopygium as explained by Crampton.

The rather numerous forms of the Schizophora with symmetrical postabdomen are probably all evolved from asymmetrical forms. It is not surprising that there should be an evolutionary tendency to restore symmetry in bilateral animals which depend on flight for survival. Most of the symmetrical forms are, judging from other characters, comparatively specialised and show a reduction in the number of postabdominal sclerites.

Steyskal differs from Crampton in calling the dorsal sclerite of the hypopygium (epandrium the fused ninth and tenth tergites. He bases this conclusion on the fact that two pairs of surstyli are often present, presuming the second pair to belong to the tenth segment. There is no evidence however, that the surstyli are segmental appendages. In almost all male Nematocera and Orthopyga where the tenth segment is distinct, it is very small and without appendages. Various stages occur between forms with better developed tenth tergite and those with none at all, as in *Oncodes*. In these forms there is no fusion of the ninth and tenth tergites, the latter being lost by desclerotization. In the least specialised of those Campylopyga (Cyclorrhapha plus Dolichopodidae) which have two pairs of surstyli, i.e., certain species of Dolichopodidae, both processes are situated on the apex of a single marginal prominence of the epandrium. It does not, therefore, seem likely that they belong to different segments. In view of the facts just expressed, the author affirms that there is no evidence for fusion of the ninth and tenth tergites in the Campylopyga. It is interesting to note that Hennig (1958) now considers the epandrium to be the ninth tergite alone.

The author disagrees with Crampton in his terminology of the appendages of the ninth abdominal sternite. The term paramere is here used as defined by Snodgrass (1935) to indicate paired lateral processes of the phallobase in holometabolous insects, which may have been derived from the gonopophyses of such primitive insects as Machilidae. The term is applied to such structures in Diptera and Coleoptera, but its use in certain other orders may be erroneous. Crampton uses the term paramere in lower Diptera to designate the outer appendages consisting of gonocoxites (basimeres or basistyles of Crampton) and their styli (distimeres or dististyles). He uses the terms pregonite and postgonite for the appendages here called parameres and considers them to be, respectively, the anterior and posterior gonopophyses. However, if the parameres are derived from gonopophyses they should each be considered as a lobe of the gonopophysis of the ninth segment and not the whole organ. Crampton's use of the term paramere for structures other than those considered to be derived from gonopophyses is not acceptable.

There is no evidence that the so-called surstyli of *Campylopyga* are homologous with the styli of the gonopods; indeed, Crampton's figure of *Syrphus rectus* (1942, Fig. 14H), where both pairs of appendages are shown, seems to preclude all possibility of this being so. The surstyli are invariably associated with the tergite and not the sternite, even in the Dolichopodidae.

Characters of the Terminalia in Clusiidae

The most important works on the morphology of clusiid terminalia are those of Hennig (1938a), Crampton (1944a) and Séguy (1934). Hennig, who apparently had insufficient material for a detailed report, failed to find the spiracles in most cases, thus missing important evidence as to the identity of the postabdominal sclerites. He apparently only examined his specimens from the right side, as his figures all show this aspect and there is no mention in the text of asymmetry or structures on the left side. Crampton figured and mentioned the terminalia of only one species, *Clusia lateralis* (Walker), but correctly identified the parts and explained the causes of asymmetry, thus laying a foundation for future work. Cole (1927) had previously given a helpful figure and description of the terminal segments of this species. Séguy figured and described the terminalia of two species of *Clusiodes*. His figures show considerable detail of the hypandrium and its appendages, but omit the spiracles and certain of the postabdominal sclerites. Malloch (1933) figured the male terminalia of several species of *Alloclusia*, but his figures, which were probably prepared by Edwards, show little detail and serve mainly to show specific differences in the form of the surstyli. This also applies to the figures and descriptions of terminalia of *Heteroneura* (i.e., *Clusiodes*) given by Collin (1912).

The terminalia of male Clusiidae are so diverse that there are few characters which may be regarded as of family value. Hennig (1939) has indicated that the holarctic genus *Acartophthalmus* does not belong to the family at all for, among other anomalous characters, there is only one sclerotized segment between the preabdomen and hypopygium. All other forms which have been investigated have two free dorsal sclerites in this region.

The sixth tergite is symmetrical or almost so, and has the sixth pair of abdominal spiracles below its lateral margins. The sixth sternite is displaced on to the left side and is generally in contact with the seventh sternite which is situated still higher on the left side. The latter sclerite is adjacent or connected to the large dorsal eighth sternite. The seventh spiracles may be asymmetrically placed, the left one being upon, or just in front of, the seventh sternite, while the right one is in the extensive membranous region of the right side. In *Tetrameringia* there is a small, weakly developed sclerite above the seventh right spiracle which is perhaps the seventh tergite (Fig. 26, t7).

In *Clusiodes gladiator* the sixth to eighth sternites differ from those of other genera, as they have become fused into a complete annulus through sclerotization of primitively membranous areas (Fig. 23). A certain degree of asymmetry is retained. The sclerotized region on the right side is attenuated behind the seventh spiracle, which is situated in the membrane. On the left side the sclerotized band is not attenuated and there is a very heavily sclerotized strip on its anterior margin which appears to represent the edges of the sixth and seventh sternites. The seventh left spiracle is situated within this marginal strip. The spiracles of the sixth pair are situated in the membrane below the lateral edges of the sixth tergite. It is not clear from the published information whether the postabdominal sternites of the other species of *Clusiodes* are free or fused. *Czernyola* is intermediate between *Clusiodes gladiator* and the other genera, as the seventh sternite is completely fused with the eighth but the sixth sternite is quite distinct (Fig. 14).

In all forms the ninth segment is deflexed and symmetrical. The ninth tergite or epandrium is large and carries one or two pairs of surstyli (gonopods and cerci of Hennig). The ninth sternite or hypandrium is smaller, and has either a concave surface into which the base of the phallus may be folded or a desclerotized central region. In some species of *Heteromeringia* only a narrow marginal sclerotized band remains. The phallus is borne on the posterior part of the ninth sternite. It is extremely variable in structure, and may be differentiated into a sclerotized phallobase and distal membranous aedeagus. The former is usually short and may have one or two pairs of parameres and a median posterior spinus ditillatorius. The aedeagus varies in length, but is often so long that it must be coiled in repose. In such cases it may be branched distally, and in *Heteromeringia* it is supported by a pair of longitudinal skeletal strips. A long apodeme is connected to the phallobase. True cerci (para-anal lobes of Hennig) are usually present in the membranous region (proctiger) surrounding the anus, but Hennig does not show them in his figure of *Sobarocephala annulata* Melander and Argo and in *Clusiodes gladiator* they are minute.

When the terminalia of the family are more thoroughly known it may be possible to distinguish most genera on these characters alone. However, caution should be exercised in using the terminalia for generic segregation unless amply supported by other characters. The following table summarizes the characters of the male terminalia in six genera, though deviations from these may be expected to occur in some of them. Of the forms dealt with by Hennig it has been possible to include *Paraclusia* (=*Stomphastica* Hendel, not Loew), because it may be reasonably assumed that the sixth and seventh sternites are as in the closely related genus *Clusia*. There is, however, insufficient information available for the inclusion of *Sobarocephala*.

Characters of the Male Terminalia of Clusiid Genera

1. Two pairs of surstyli; parameres absent; spinus ditillatorius present 2
   One pair of surstyli; parameres present 3

2. Aedeagus branched distally .... *Paraclusia*
   Aedeagus not branched .... *Clusia*

3. Aedeagus spirally coiled; sternites six to eight distinct from one another; two pairs of parameres; spinus ditillatorius present 4
   Aedeagus not, or but slightly, coiled; sternites seven and eight fused; one pair of parameres 5

4. Aedeagus with a pair of longitudinal pigmented skeletal strips .... *Heteromeringia*
   Aedeagus without pigmented skeletal strips .... *Tetrameringia*

5. Sternites six to eight not forming an annulus, sternite six distinct; spinus ditillatorius present; phallobase very short .... *Czernyola*
   Sternites six to eight fused into a complete annulus; spinus ditillatorius absent; phallobase elongate .... *Clusiodes*

The Origin of the Australian Clusiid Fauna

The genus *Clusiodes* is widespread, occurring in the Nearctic, Palaearctic and Oriental Regions, but it has not been previously recorded from the Southern Hemisphere. Most of the species occur in the Nearctic and Palaearctic Regions; none is known from the Neotropical Region, where the allied genus *Labomyia* occurs. It seems that *Clusiodes* has entered Australia from the Oriental Region during the Tertiary.

The occurrence of the genus *Heteromeringia* in both the Neotropical and Indo-Australian Regions was considered by Hennig (1938a) to be of special interest. However, as the genus also occurs in the Nearctic Region, Palaearctic Region (one specimen known) and Ethiopian Region (Seychelles), the distribution is almost cosmopolitan. It seems likely that the genus has entered Australia in the same way as *Clusiodes*. There are more known species of *Heteromeringia* in the Australian Region than in any other, and it is the only genus of the family known from Tasmania and Western Australia.

Czernyola has a less extensive distribution than *Heteromeringia*, but the differences are mainly due to its not extending so far beyond the tropics. It occurs from the Neotropical Region through Oceania to Formosa, the Philippines, Guam and eastern Australia, but does not extend as far west as *Heteromeringia* in the Old World tropics.

Allometopon is essentially an Indo-Australian genus. The typical forms may be considered as belonging to the Papuan Subregion, though extending south almost to the border of New South Wales and Queensland. Another group consists of two Philippine species, while a third is represented by one species from the Seychelles, an outlying part of the Ethiopian Region.

Tetrameringia, though endemic in temperate Australia, appears to be allied to the southern neotropical genera *Alloclusia* and *Apiochaeta*. The relationship between the fauna of southern South America, New Zealand and southern Australia has been much discussed. It is certain that some migration route for land animals has either enabled animals to enter all three regions from a common source or allowed migration between these regions. Hennig has associated *Alloclusia* and *Apiochaeta* with the northern temperate genera *Clusia* and *Paraclusia* [*Stomphastica*], but the author can find no important points of resemblance.

The Australian genus *Parahendelia* is endemic and most closely allied to the geographically remote *Hendelia* of Europe. These genera are probably relicts of a previously widely distributed group. It is possible that related forms will yet be found in intermediate localities, as the known forms are rare.

The main points regarding the origin of the Australian forms may be summarized as follows : the Australian clusiid fauna has entered the continent by two main paths. All the genera but one are of northern origin, though outside Australia each of these has a different distribution pattern. *Tetrameringia* is the only genus which shows relationship with the Chilean Subregion of the Neotropical Region, and is therefore of southern or south-eastern origin.

SYSTEMATIC TREATMENT

Key to Genera of Clusiidae

(Genera known to occur in Australia are indicated with an asterisk).

1. Foremost pair of fronto-orbitals incurved or proclinate, the others reclinate 2
   Foremost pair of fronto-orbitals reclinate, though sometimes slightly sloping inwards 10

2. Interfrontal bristles present 3
   Interfrontal bristles absent.. 4

3. Postvertical and prescutellar acrostichal bristles present; Europe.... *Paraclusia* Czerny
   Postvertical and prescutellar acrostichal bristles absent; Holarctic .... *Clusia* Haliday

4. Postverticals absent; first vein setulose above; America, mainly tropical .... *Chaetoclusia* Coquillett
   Postverticals present; first vein not setulose 5

5. Presutural dorsocentral and preapical tibial bristles present 6
   Presutural dorsocentral bristles absent 7

6. Presutural bristle about as long as presutural dorsocentral bristle; three or four fronto-orbitals; southern Neotropical........................ *Alloclusia* Hendel
   Presutural bristle very short and fine, sometimes scarcely distinguishable; three fronto-orbitals; southern Neotropical........................ *Apiochaeta* Czerny

7. Arista lanceolate, densely pubescent; presutural bristle present; Formosa .... *Phylloclusia* Hendel
   Arista filiform 8

8. Presutural bristles and prescutellar acrostichals well developed; preapical tibial bristles minute; four fronto-orbitals; Australia................ **Tetrameringia* nov.
   Presutural bristles absent; prescutellar acrostichals small or absent; three, or rarely two, fronto-orbitals 9

9. Preapical tibial bristles well developed at least on middle tibiae; length of penultimate section of fourth vein about one-third that of ultimate section; America, mainly tropical.. *Sobarocephala* Czerny
   Preapical tibial bristles absent; length of penultimate section of fourth vein at most about one-quarter that of ultimate section; widely distributed..**Heteromeringia* Czerny

10. Interfrontal bristles absent; preapical tibial bristles present 11
    Interfrontal bristles present 12

11. Two reclinate fronto-orbitals only; Samoa, Formosa .... *Isoclusia* Malloch
    Four or five fronto-orbitals, one of the middle ones incurved, the others reclinate; Neotropical Region through Oceania to Formosa and Australia .. **Czernyola* Bezzi

12. A large style-like process arising from the centre of each eye; two fronto-orbitals; interfrontals very long, widely separated, and inserted near middle of frons; Peru .... *Labomyia* Frey
    No such process on eye 13

13. Preapical tibial bristles absent; postverticals small or absent; interfrontals inserted near ptilinal suture; Australian and Oriental Regions, Seychelles.. **Allometopon* Kertész
    Preapical tibial bristles well developed 14

14. Interfrontals inserted well above ptilinal suture between longest pair of fronto-orbitals; frons and face not exceptionally broad; antennae normally inserted; widely distributed .... **Clusiodes* Coquillett
    Interfrontals inserted very close to ptilinal suture; frons and face exceptionally broad; antennae inserted very far apart and close to eyes 15

15. Second antennal segment very short; arista thickened; postverticals absent; interfrontals small and close together; Europe .... *Hendelia* Czerny
    Second antennal segment about as long as third or longer; arista filiform; postverticals well developed; interfrontals long and widely separated; Australia.. **Parahendelia* nov.

The last published key to the genera of Clusiidae is that of Melander and Argo (1924), on which the above key is partly based. Four additional genera are now included. The genus *Acartophthalmus* Czerny is omitted, as it probably does not belong to the Clusiidae (Hennig, 1939, 1958). The genus *Cypselosoma* Hendel (1913) has been placed in the Cypselinae (i.e., Sphaeroceridae) and in the Tylidae (Micropezidae), but more recently has been placed in the Clusiidae by Hennig (1948) in a paper not available to the author. Hennig (1952), however, returned the genus to the Tylidae, and still later (1958) set up a new family, Cypselosomatidae, to contain it.

The author agrees with Hennig (1938b) that the restoration by Hendel (1931) of the name *Stomphastica* Loew for the genus usually called *Paraclusia* Czerny is incorrect. *Stomphastica* was introduced as a substitute for *Clusia* Haliday, and is therefore an exact synonym of it.

The practice of indiscriminately designating allotypes is not here followed as, in the author's opinion, it serves no useful purpose. Unless taken in copula with a male holotype, there is no reason for accepting any one female as more authentically representative of the species than any other in the paratype series.

Genus **Tetrameringia** nov.

Head not much higher than long; ocellars and postverticals well developed; four fronto-orbitals, the foremost one more or less incurved; no interfrontals; lunule covered; antenna with subdiscoid third segment and slender, apical arista. Thorax with well developed presuturals and prescutellar acrostichals; foremost dorsocentral bristle well behind suture and very short; propleurals represented by two fine hairs (proepimeral and proepisternal); tibiae with preapicals vestigial; venation as in *Alloclusia*.

Type species : *T. ustulata* sp. nov.

This genus most closely resembles the neotropical *Alloclusia* Hendel, but all the dorsocentrals are far behind the suture, the foremost pair being very small, and the prescutellar pair of acrostichals is well developed. It differs from *Sobarocephala* Czerny in having the head not much higher than long, in having four instead of three fronto-orbitals, and in the strongly developed ocellar and presutural bristles.

The small size of the preapical tibial bristles would also appear to distinguish the genus from *Alloclusia* and *Sobarocephala*. The presence or absence of these bristles has been considered of generic importance, and is the principal distinction between *Sobarocephala* and *Heteromeringia*. The author has not seen any specimens of *Alloclusia*, but Malloch (1933) states that there is a short apical bristle on the mid tibia. Czerny (1903) states that the preapical bristles on the fore and middle legs are distinct (deutlich) while Melander and Argo merely indicate their presence on the middle tibiae. In *Sobarocephala* these bristles are also well developed. In *Tetrameringia* they are very short on the fore tibiae and may be indistinguishable on the middle ones. They are always absent on the hind tibiae.

Alloclusia is as distinct from *Tetrameringia* as it is from *Apiochaeta*, and may be regarded as intermediate between these two genera. It includes species with four fronto-orbitals, as in *Tetrameringia*, and others with three fronto-orbitals, as in *Apiochaeta*.

Key to Species of Tetrameringia

1. Arista with longer hairs about twice as long as its basal diameter; thorax with a blackish spot on mesopleuron, otherwise unmarked; prescutellar acrostichal over half the length of posterior dorsocentral .... *ustulata* nov.

Arista with short pubescence only; thorax with black marks on mesopleuron and metapleuron and a black stripe on each side of mesonotum, interrupted at suture; prescutellar acrostichal bristle not more than half the length of posterior dorsocentral .... *pubescens* nov.

Tetrameringia ustulata sp. nov.

(Figs. 1, 5, 26)

♂♀. Colour light brownish-yellow, somewhat shining; antennal arista, all bristles and most hairs black; a brown spot between ocelli; a large brown-black spot on upper part of mesopleuron, the thorax otherwise unmarked; hind tibiae brown centrally, the legs otherwise unmarked. Wings hyaline, with a blackish mark extending from fifth vein to costa across end of discal cell and just beyond apex of first vein, thence along costa to fourth vein, where it becomes wider and more diffuse. Abdomen black, except at base.

Head about one and a half times as high as long; frons almost as wide as long, and about two-fifths as wide as head; cheek in middle region about one-eighth height of eye, lower margin almost straight and ascending anteriorly; postgenal region ventrally prominent and with a ventrally directed bristle; postvertical and ocellar bristles subequal, long, but shorter than the verticals; fronto-orbitals subequal, successively further apart from front to rear; a series of cheek hairs behind vibrissa; second antennal segment with a long terminal dorsal bristle; arista with longer hairs about twice as long as its basal diameter.

Thorax with the following bristles : two short, fine propleurals; one mesopleural; one sternopleural; one humeral; a long presutural; two notopleurals; supra-alar; a very long postalar; posterior intra-alar; three or four dorsocentrals, the foremost often scarcely distinguishable from the surrounding hairs; a pair of well-developed prescutellar acrostichals; four marginal and two discal scutellars, apical ones longest, others subequal. Mesoscutum and posterior part of mesopleuron with numerous hairs. Femora with a row of postero-ventral bristles, those on the middle and hind femora sometimes undeveloped; fore and middle tibiae with very small preapical dorsal bristles, sometimes indistinguishable on the latter; middle tibiae with several apical spurs; hind tibiae with two short, unequal spurs. Wings with preapical section of fourth vein about one-third as long as apical section, and subequal to apical section of fifth vein; discal cell acute at posterior apex.

Dimensions : total length, 3·2-4·5 mm.; length of thorax, 1·5-1·6 mm.; length of wing 3·4-4·2 mm.

Distribution : New South Wales—Central Coast and Tableland. Sassafras Gully Springwood, Blue Mountains, January 10, 1956 (holotype ♂, paratype ♀). Wentworth Falls, Blue Mountains, February 2, 1957 (paratypes, 1 ♂, 2 ♀), January 31, 1959 (paratype ♂). National Park, south of Sydney, December 31, 1955 (paratype ♂). Otford, Illawarra district, January 27, 1958 (paratype ♂); January 26, 1959 (paratypes, 3 ♂, 9 ♀). All collected by D. K. McAlpine.

Habitat : on banks of creeks in and near rain forest, not found above 1,400 ft.

Location of types : Australian Museum.

An abnormal male specimen from Otford measures only 3·0 mm. in total length, length of thorax being 1·3 mm. and length of wing 2·8 mm. The incurved pair of fronto-orbitals is undeveloped in this specimen, the left one being represented by a small hair, the right one absent altogether.

Tetrameringia pubescens sp. nov.

♂. Colour brownish-yellow, somewhat shining; arista, bristles, and most hairs of head and thorax, black; all bristles, spurs, and hairs on legs yellow or yellowish-brown; ocellar spot black; a large black spot on mesopleuron and another covering metapleuron; mesoscutum with a longitudinal black stripe on each side between dorsocentrals and supra-alar, interrupted at suture and not reaching humeral callus; legs unmarked; abdomen black, the first segment yellowish-brown. Wings hyaline with a greyish cloud along distal half of costal margin and a smaller separate cloud around posterior crossvein.

Head similar structurally to that of *T. ustulata*, but bristles and cheek hairs relatively shorter; second fronto-orbital not closer to first than to third, the first more distinctly reclinate than in *T. ustulata* and less strongly incurved; arista with short pubescence only.

Thoracic chaetotaxy as in *T. ustulata*, but most bristles somewhat shorter. Fore and middle femora with postero-ventral bristles; preapical tibial bristles almost indistinguishable; tibial spurs less developed than in *T. ustulata*. Preapical section of fourth vein about two-fifths as long as apical section; venation otherwise similar to that of *T. ustulata*.

Dimensions : total length, 2·4 mm.; length of thorax, 1·1 mm.; length of wing, 2·0 mm.

Distribution : New South Wales—Blue Mountains. Mount Wilson, March 2, 1957 (holotype ♂), D. K. McAlpine.

Habitat : partly cleared rain forest, circa 3,000 feet.

Location of type : Australian Museum.

Genus **Heteromeringia** Czerny

The genus is easily recognized from the key. Melander and Argo state that the propleural bristles are absent, but in most Australian species they are represented by small hairs. A character of the males not previously noted is a small, round, raised plate on the mesopleuron, below and in front of the mesopleural bristle. It occurs in the males of all Australian species, with the possible exception of *H. imitans*, which the author has not seen. This structure has not been observed in other genera. Hennig (1958) refers to *Heteromeringia* as being without a break in the costa or a distinctly soft central region of the face. In material the author has examined the costa is incised at the end of the subcosta, though less conspicuously so than in other genera, and the face is only sclerotized on its upper part between the antennae. In these characters *Heteromeringia* agrees with all other clusiid genera seen by the author.

The species are more difficult to separate than those of other Australian genera and, though colour differences are important, some intra-specific variation is present. It is, therefore, desirable to include details of the antennae and male terminalia in all descriptions. The most important specific characters in the terminalia are the form of the surstyli and the number and structure of the appendages of the aedeagus. The latter consist of the two branches of the distal fork, to which the terms anterior and posterior are applied to indicate their positions when the aedeagus is ventrally directed and untwisted. The posterior distal branch may have a pair of terminal filaments, or there may be a short intermediate branch between those of the distal fork. In addition, up to three lobes may be present proximally to the distal fork.

Unlike the other species of the family, which I have only taken in or near rain forests along creeks, those of this genus are often found in the more open eucalypt forests.

Key to Australian Species of Heteromeringia

1. Lower half of pleura and a broad median area on mesonotum, pale yellowish; arista with longest hairs no shorter than its basal diameter; third antennal segment porrect; ocellars minute; wings with only the apical cloud distinct; only the front legs with dark markings. Queensland .... *hypoleuca* nov.

   Thorax almost entirely black 2

2. Halteres black; wings with only the apical dark cloud; coxae and femora entirely yellowish; ocellars very small. Queensland .... *imitans* Malloch

   Halteres with yellowish knobs; other characters not all as above 3

3. Wing with three incompletely separated transverse blackish patches; ocellars about half as long as postverticals; pubescence on arista more than half as long as basal diameter of latter; third antennal segment porrect 4

   Wing with, at most, two principal dark patches; ocellars almost or quite as long as postverticals; pubescence on arista not more than half as long as basal diameter; third antennal segment slightly decumbent 6

4. Mesonotum with a pair of narrow yellow-brown bands along dorsocentral lines behind suture; fore legs, except bases of tibiae but including coxae, entirely blackish; surstyli not distinctly curved, tapering only in distal half; aedeagus with posterior branch of distal fork longer than anterior one and expanded into a large membranous disc at apex. New South Wales .... *australiae* Malloch

   Mesonotum without pale bands; fore legs with at least the coxae pale yellowish; middle and hind legs almost entirely yellowish to brownish-yellow; surstyli curved; aedeagus with posterior branch of distal fork no longer than anterior branch.............. 5

5. Ventral margin of cheek entirely yellow; anterior margin of frons yellow; surstyli curved near base where they are comparatively narrow, not notably tapering; aedeagus with posterior branch of distal fork broad, the apical part expanded into a bell-shaped structure. New South Wales, Tasmania .... *spinulosa* nov.

   Posterior part of cheek, including ventral margin, entirely black; frons entirely black, but the anterior margin sometimes deep brown; surstyli falcate, broad basally, thence gradually tapering almost to apex; aedeagus with posterior branch of distal fork short and narrow. New South Wales .... *pulla* nov.

6. Legs, including the coxae, predominantly deep brown, the fore legs with tarsi not darker than the tibiae; third antennal segment not wider than second; propleural hair usually absent; surstyli more than twice as long as wide, gradually tapering; aedeagus with a pair of moderately long terminal filaments. Western Australia .. .. *norrisi* nov.

   Fore coxae and other extensive regions of legs pale yellowish; propleural hair present 7

7. Third antennal segment wider than second; distal parts of fore and hind femora broadly black; fore legs with tarsi black and tibiae yellowish in male (female unknown); legs otherwise unmarked; surstyli subtriangular, not distinctly longer than broad; aedeagus without terminal filaments. New South Wales.... *laticornis* nov.

   Third antennal segment not wider than second; legs otherwise marked 8

8. Fore tibia and apex of fore femur brown-black, fore tarsus black in both sexes, legs otherwise yellowish; third antennal segment not very notably decumbent; arista with longest hairs fully half as long as its basal diameter; surstyli not distinctly longer than basal width; aedeagus without terminal filaments. New South Wales .... species A.

   Fore tibia yellowish, fore tarsus black in female only, apices of femora at most narrowly browned; third antennal segment distinctly decumbent; arista with longest hairs less than half as long as its basal diameter; surstyli broad basally, contracted into a narrow distal part; aedeagus with a pair of long terminal filaments. New South Wales .... *hardyi* nov.

Heteromeringia hypoleuca sp. nov.

(Fig. 29)

♂♀. Head pale yellowish; only the ocellar spot and upper half of occiput blackened in male; the entire frons, a part of the postgena and a variable amount of parafacials and anterior part of cheek blackened as well in female; antennae slightly browned at apices. Thorax pale yellowish with, in the female, a broad dark-brown longitudinal band on each side of mesonotum, extending from neck region on to sides of scutellum, and a somewhat narrower band across upper parts of pleura, beginning on propleuron and expanded posteriorly to cover the metanotum and postnotum; male with the above bands extensively interrupted and much paler in part. Fore tibia with a longitudinal black stripe on each side (anterior and posterior), which is broader in female; blackish spot on distal part of fore femur in female; legs otherwise entirely yellowish. Bristles of head and thorax yellowish-brown to black. Wings hyaline, with a greyish distal cloud, and a very indistinct one in region of discal cell. Abdomen dark brown to black.

Head rather higher than long; cheek one-seventh to one-eighth height of eye; ocellars minute, not longer than the diameter of an ocellus; cheek hairs rather long, but much shorter than vibrissa, which is about one and a half times as long as antenna (excluding arista); eyes with sparse minute hairs; third antennal segment almost as wide as second, porrect; arista with the longest hairs about as long as its basal diameter.

Thorax, including mesopleuron, almost without pubescence or dust, largely shining, propleural hair present; mesopleuron with fine setulae on posterior part and one long bristle; mesopleural plate of male convex, with roughened or pubescent surface; male with a series of postero-ventral bristles on fore and middle femora; female with a few postero-ventral bristles on fore femur only. Wings normal.

Surstyli of male elongate oval, slightly narrowed at base, outer surface with fine sparse hairs; cerci of male very narrow, joined for most of their length; aedeagus withdrawn in holotype and no details visibile.

Dimensions : total length, ♂ 4·2 mm., ♀ 3·6-4·2 mm.; length of thorax, ♂ 1·3 mm., ♀ 1·2-1·4 mm.; length of wing, ♂ 3·7 mm., ♀ 3·0-3·3 mm.

Distribution : Queensland. Lamington National Park, October 29, 1955 (holotype ♂, paratype ♀), F. A. Perkins. Coolum, April 20, 1938 (paratype ♀), F. A. Perkins. Kuranda, December 22, 1958 (1 ♂), D. K. McAlpine.

Location of types : holotype in Queensland Museum; paratypes in Entomology Department, University of Queensland; Kuranda specimen in Australian Museum.

Habitat : Kuranda specimen in rain forest.

The holotype male specimen differs in a number of ways, mainly in colour, from the two female specimens. These differences have been noted in the above description, but it is not possible to be sure if some of these are sexual differences or individual variation. The specimens from Lamington National Park and Kuranda differ from the one from Coolum in having the dark bands on the mesonotum broadly connected anteriorly instead of quite separate, as in the latter. The Kuranda specimen differs from the holotype male in having the frons black with an orange-brown median anterior patch. It also differs from all the specimens from southern Queensland in having the two basal segments and basal part of third segment of fore tarsus black. This may represent a northern subspecies.

Heteromeringia imitans Malloch, 1930

The author has not seen this species, which is only known from the type specimen. The description is rather brief, but the species should be easy to recognize. No other Australian species has the halteres black, and in addition, it is the only one of the predominantly black species which has only one dark cloud on the wing in combination with very short ocellars.

Distribution : North Queensland. Cairns (holotype).

Location of type : Deutsches Entomologisches Institut, Berlin.

Heteromeringia australiae Malloch, 1926

(Fig. 28)

No specimen other than the holotype can at present be referred to this species. Lee, Crust and Sabrosky (1956) failed to locate the allotype, but a female specimen in the same institution as the holotype bears identical data to the allotype and differs from the holotype in the same points as noted by Malloch. It is therefore probably the allotype, but is referable to *H. spinulosa* rather than to this species.

The main differences of this species from *H. pulla* and *H. spinulosa* are noted in the key, but some variation in the characters cited may be noted when more material is studied. The wing colouring as given in the original description is misleading, as the dark area extends almost to the base and is incompletely divided into three. The halteres of the holotype are now yellow-brown, but may have become darkened with age, as Malloch stated that they were yellowish.

The terminalia were examined on the intact specimen : aedeagus with posterior branch of distal fork longer than anterior branch, expanded into a flat membranous disc at apex; surstyli almost lanceolate, acute.

Some additional characters were noted. Mesopleural plate larger than in other species, appearing as a round yellow disc with raised margins and dull surface. Propleural hair well developed. Third antennal segment porrect, distinctly narrower than second. Dimensions of holotype : total length 4·7 mm., length of thorax 1·8 mm., length of wing 4·8 mm.

Distribution : New South Wales—North Coast. Coramba (holotype).

Location of type : School of Public Health and Tropical Medicine, University of Sydney.

Heteromeringia pulla sp. nov.

(Fig. 4, 6, 34, 35)

♂♀. General colour black. Face and anterior part of cheeks reddish-brown to yellowish; upper part of cheek silvery-dusted; eyes conspicuously red in life (field observation); palpi brown distally or entirely yellowish; antennae yellowish, apex of third segment usually darker; arista blackish. Fore femur yellowish to brown; fore tibia brown to almost black; fore tarsus black, except for the brownish apical segment; middle and hind legs, except the coxae, brownish-yellow; all coxae pale yellowish. Wings extensively blackish, the dark area incompletely divided into three by transverse hyaline bands. Halteres with brown stalks and whitish clubs. Abdomen entirely black.

Head about as long as high; frons about one-third as wide as head; cheek about one-seventh to one-ninth as high as eye; ocellars about half as long as postverticals; foremost pair of fronto-orbitals appearing erect in profile, strongly incurved; second pair recurved, but also curved inwards; vibrissa about as long as antenna, the cheek hairs about half as long; third antennal segment porrect, as wide as second segment; arista with longer hairs about as long as its basal diameter.

Thorax with normal chaetotaxy; propleural hair present; mesopleural setulae fine; mesonotum, metanotum, sternopleuron (except upper margin) and a small posterior part of mesopleuron, finely dusted; mesopleural plate of male yellowish grey, slightly raised. Fore tarsus strongly bilaterally compressed, its maximum diameter equal to that of tibia; fore and middle femora of male with series of antero-ventral and postero-ventral bristles, the latter better developed; these bristles much less developed in female; hind femur with a few antero-ventral bristles only. Wing as in Fig. 6.

Male postabdomen with surstyli falcate, broad basally and tapering to near apex; aedeagus with additional melanized branch between those of the distal fork, posterior branch of fork narrow, without terminal filaments, a lobe with weakly serrated melanized margin before the fork, and proximal to this lobe a short, triangular, entirely melanized lobe.

Dimensions : total length, ♂ 2·7-3·3mm., ♀ 3·5-3·9 mm.; length of thorax, ♂ 1·0-1·3 mm., ♀ 1·2 mm.; length of wing, ♂ 2·1-3·0 mm., ♀ 2·9 mm.

Distribution : New South Wales—Central Coast. National Park, south of Sydney, April 13, 1957 (holotype ♂, paratypes, 4 ♂), April 20, 1957 (paratypes, 4 ♂), January 28, 1957 (paratype ♀), D. K. McAlpine. Otford, Illawarra District, January 26, 1959 (paratype ♀), D. K. McAlpine.

Habitat : wet sclerophyll and dry sclerophyll forest.

Location of types : Australian Museum.

This species was observed on fallen limbs and bark of *Eucalyptus*, moving the wings alternately up and down in a manner suggestive of certain of the Sepsidae, Platystomatidae and Trypetidae. All the specimens captured in this situation were males, but, as one pair was seen in copula, females were also present.

Heteromeringia spinulosa sp. nov.

(Fig. 27)

♂. Colour generally as described for *H. pulla*, but the following characters are notable. Anterior margin of frons, face and entire cheeks, except upper postgena, yellowish; frontal orbits yellow-brown; palpi and antennae yellowish; arista blackish. Thorax with variable yellowish-brown patches on propleuron, pteropleuron, hypopleuron, sides of scutellum and postero-lateral corners of mesoscutum. Halteres with pale brown stalks and pale yellowish knobs.

Head deformed in holotype, in paratype similarly formed to that of *H. pulla*, but slightly higher in proportion to length, the cheek almost one-fifth as high as the eye. Chaetotaxy of head and general characters of thorax as described for *H. pulla*. Legs and wing as in *H. pulla*.

Surstyli curved near their bases, narrow throughout and only sightly tapered; aedeagus with a small melanized lobe between those of distal fork; posterior branch of fork expanded into a bell-shaped structure, without filaments; a lobe present before fork as in *H. pulla*, but more narrowly melanized and very weakly serrate on margin; in addition, two lobes basal to this, the more basal one short and rounded, the other typically very long, directed towards base of aedeagus and heavily melanized with spinose-serrate margin—in one specimen very short, as in *H. pulla*.

Dimensions : total length, ♂ 3·0 mm., ♀4·4-5·2 mm.; length of thorax, ♂ 1·2-1·3 mm., ♀ 1·7-1·9 mm.; length of wing, ♂ 2·9 mm., ♀ 3·8-4·3 mm.

Distribution : New South Wales—Coast and Tablelands; Tasmania—West Coast. New South Wales : below Govett's Leap, Blue Mountains, December 7, 1956 (holotype ♂) D. K. McAlpine; Otford, Illawarra district, October 12, 1957 (paratype ♂), D. K. McAlpine; Katoomba, Blue Mountains, November 2, 1957 (1 ♂), G. H. Hardy; Lawson, Blue Mountains, December 3, 1956 (1 ♀), D. K. McAlpine; Sydney (i.e., probably Sydney district), February 1925 (1 ♀, probable allotype of *H. australiae* Malloch), Health Department. Tasmania : Strahan, February, 1924 (1 ♀), G. H. Hardy.

Habitat : in rain forest on banks of creeks; specimen from Lawson on dense weed growth near a roadside gutter.

Location of material : Holotype, paratype and specimens from Katoomba and Lawson in Australian Museum; specimen from Sydney in School of Public Health and Tropical Medicine, University of Sydney; specimen from Strahan in Entomology Department, University of Queensland.

The female specimens differ from the males in their much larger size. In other species of the genus the sexual difference in size is very slight. In all other characters, except for the reduced bristling of the legs, a sexual character, they resemble the males. It is probable that these specimens are not specifically distinct from the males, but in view of the small specific differences in *Heteromeringia* they are not designated as paratypes.

The male specimen from Katoomba differs from the other two males in its slightly darker colouring and reduction of the melanized lobe proximal to fork of aedeagus. In coloration of head, width of cheek and other characters of the terminalia it agrees with this species and not the previous one.

Heteromeringia norrisi sp. nov.

(Figs. 7, 30)

♂♀. Colour deep brown to brown-black. Antennae, anterior edge of frons, anterior part of cheek, mouthparts and a variable amount of face brownish-yellow. Legs, including coxae, deep brown; knees, bases of femora and middle of hind tarsus sometimes yellowish. Wings with a greyish cloud over apices of second and third veins, sometimes extending over fourth vein, and a fainter cloud over anterior crossvein and discal cell. Halteres pale yellowish with brown stalks.

Head slightly higher than long; vibrissae no longer than antennae; cheek hairs small; eyes with sparse minute hairs; third antennal segment somewhat decumbent, not wider than second; arista with pubescence not over one-quarter as long as its basal diameter.

Thorax with normal chaetotaxy; propleural hair absent or, in some specimens, visible on one side only; mesopleuron shining, almost undusted, with hairs on posterior part, but only one distinct bristle; mesopleural plate of male small, covered with greyish pubescence. Fore femur

with postero-dorsal, antero-ventral and postero-ventral bristles, the latter in a complete series in male; middle femur with antero-ventral and postero-ventral bristles in male only, the latter series complete; hind femur with antero-ventral bristles in male only; fore tarsus of female dilated, maximum diameter almost equal to that of tibia, that of male only slightly dilated. Wing venation normal.

Male terminalia similar to those of *H. hardyi*, but the surstyli gradually tapered to near apex and the terminal filaments of aedeagus comparatively shorter.

Dimensions : total length, ♂ 3·0-3·8 mm., ♀ 3·8-5·0 mm.; length of thorax, ♂ 1·1-1·5 mm., ♀ 1·3-1·8 mm.; length of wing, ♂ 2·5-3·0 mm., ♀ 3·0-4·0 mm.

Distribution : Western Australia—near Perth. Applecross, collected in rotting wood, June 10, 1934, except one collected July 1, emerged July 18-August 4, 1934 (holotype ♂, paratypes 4 ♂, 9 ♀). Cannington, September 2, 1934 (paratype ♀). All collected by K. R. Norris.

Habitat : specimens from Applecross bred from rotting wood; one female is labelled "In log with termites".

Location of types : holotype and 12 paratypes in Division of Entomology Museum, C.S.I.R.O., Canberra; two paratypes in Australian Museum.

Heteromeringia hardyi sp. nov.

(Figs. 2, 31, 36)

♂♀. Colour black. Anterior part of frons, face, anterior part of cheeks, mouth-parts and antennae brownish-yellow; apex of third antennal segment brown to black. Thorax without paler markings. Legs yellowish, the knee region of fore and hind and sometimes of middle legs dark brownish; fore tarsi black in female only; middle and hind coxae partly brown. Wings with a grey cloud over distal parts of second to fourth veins, which is darkest near second vein, and a less distinct cloud in the region of the discal cell. Halteres whitish with pale brown stalks. Abdomen black in male, brown in female.

Head slightly higher than long; frons about one-third the width of head in male, slightly less in female; cheek about one-sixth to one-fifth the height of eye; ocellars about as long as postverticals; vibrissa about as long as antenna excluding arista; cheek hairs short; eyes with sparse minute hairs; third antennal segment somewhat decumbent, as wide as second; arista with pubescence less than half as long as the basal diameter.

Thorax with normal chaetotaxy; propleural hair well developed; mesopleuron dusted on posterior half and with a few posterior hairs; mesopleural plate of male small, with short, dense, greyish pubescence. Male with antero-ventral bristles on distal part of femora, almost obsolete on the hind ones; postero-ventral bristles in almost complete series on fore and middle femora, the former with postero-dorsal bristles as well; all these bristles less developed in female; fore tarsus of female compressed and vertically dilated, tapering apically, maximum diameter greater than that of tibia; fore tarsus of male only slightly thicker than other tarsi. Wing venation normal.

Surstyli broad basally, then contracted into a narrow, elongate distal part with about five short spines at apex on inner surface; anterior paramere with a large anterior and small posterior bristle; aedeagus with a pair of very long terminal filaments; anterior branch of apical fork short; no well developed additional lobes.

Dimensions : total length, ♂ 3·1-3·5 mm., ♀ 3·0-4·5 mm.; length of thorax, ♂ 1·4-1·5 mm., ♀ 1·2-1·7 mm.; length of wing, ♂ 3·0-3·2 mm., ♀ 2·5-4·0 mm.

Distribution : New South Wales—Blue Mountains. Katoomba, December 19, 1956 (holotype ♂, paratypes, 2 ♀), November 23, 1956 (paratype ♀), December 17, 1956 (paratype ♀), December 18, 1956 (paratype ♀), December 29, 1956 (paratype ♂), November 16, 1957 (paratype ♀), November 23, 1957 (paratype ♀), December 6, 1958 (paratype ♂), G. H. Hardy.

Location of types : Australian Museum.

Heteromeringia laticornis sp. nov.

(Figs. 3, 3A, 32)

♂. General colour black. Face, anterior margin of frons, anterior part of cheeks, proboscis, palpi and antennae yellowish; arista dark brown. Thorax without pale markings. Legs yellowish; fore tarsus and distal parts of fore and hind femora black. Wings hyaline; a greyish cloud on anterior apical margin only.

Head distinctly higher than long; frons about two-fifths as wide as head; cheek about one-seventh to one-fifth as high as eye; ocellars slightly shorter than postverticals; vibrissae shorter than antennae; cheek hairs short; third antennal segment decumbent, wider than long and wider than second segment; arista with minute pubescence which is not half as long as the basal diameter.

Thorax, including mesopleuron, extensively finely dusted; chaetotaxy normal; a small propleural hair present; mesopleural hairs very short and fine; mesopleural plate small, dull greyish, convex. Fore tarsus compressed, the maximum diameter less than that of tibia; fore and middle femora with series of postero-ventral bristles and a few antero-ventral bristles. Wing venation normal.

Surstyli subtriangular, about as long as basal width, with convex anterior margin and a compact group of short, stout spines at apex; aedeagus with both branches of distal fork slender and simple, without terminal filaments; two broad lobes before the distal fork.

Dimensions : total length, 2·4-2·5 mm.; length of thorax, 1·0-1·1 mm.; length of wing, 2·3-2·4 mm.

Distribution : New South Wales—Central Coast. National Park, south of Sydney, March 19, 1957 (holotype ♂). Otford, Illawarra District, October 12, 1957 (paratype ♂). Collected by D. K. McAlpine.

Habitat : wet sclerophyll forest and rain forest.

Location of types : Australian Museum.

Heteromeringia sp. A

(Fig. 33)

Very similar to *H. laticornis*, differing in coloration of legs, form of third antennal segment, and the slightly longer aristal hairs, as indicated in the key. Male terminalia as in that species, the form of surstylus very similar, but only one lobe visible before fork of aedeagus.

Dimensions : total length, ♂ 2·1 mm., ♀ 3·0 mm.; length of thorax, ♂ and ♀ 1·0 mm.; length of wing, ♂ 1·9 mm., ♀ 2·4 mm.

Distribution : New South Wales—Central Coast. Bronte, near Sydney, March 31, 1958 (1 ♂). Otford, Illawarra District, January 26, 1959 (1 ♀). Collected by D. K. McAlpine.

This form may be a variation of *H. laticornis*, but the characters of antennal structure and leg colour are constant in both specimens and therefore suggest that it may be distinct. A longer series of specimens will be necessary to decide the status of the two forms.

Genus **Czernyola** Bezzi, 1907

Synonyms : *Craspedochaeta* Czerny, 1903, not Macquart, 1851. *Tonnoiria* Malloch, 1929 (as full genus), synonymized Malloch, 1942.

Fronto-orbitals four or five, the second or (when five are present) the third from front directed inwards and forwards, the remainder reclinate; interfrontals absent; postverticals and ocellars present; antennae normal. One to three dorsocentrals, situated behind suture; presutural bristle absent. Preapical tibial bristles well developed. Abdominal characters : see section on male terminalia and description of *C. delta* below. Wing venation similar to that of *Clusiodes*.

Type species : *Craspedochaeta transversa* Czerny (Melander and Argo, 1924).

The incurved bristles near the centre of the frontal orbits in *Czernyola* have been frequently referred to as cruciate bristles situated in the orbits. The author follows Malloch (1929, 1933, 1942) and Hennig (1938a) in regarding these bristles as true fronto-orbitals. Cruciate or interfrontal bristles are, by definition, situated on the interfrontalia and not on the frontal orbits. Because of this interpretation it is necessary to re-evaluate the numbers of fronto-orbitals given in early descriptions.

Melander and Argo (1924) gave a key to the species then known, but is was not until Hennig (1938a) dealt with the genus that a more satisfactory scheme of grouping the species was put forward. Hennig did not, however, definitely recognize *Tonnoiria* as congeneric, though he suggested that *C. biseta* Hendel might be better placed in that genus.

The species are divisible into three groups which may be of subgeneric value. However, the author does not consider that the present knowledge of the group is adequate to establish subgenera, especially as the groups are differentiated only by single bristle characters.

Key to Species Groups of Czernyola

1. Four strong reclinate fronto-orbitals in addition to the incurved one; neotropical .... *transversa* group
   Three reclinate fronto-orbitals 2

2. One strong pair of dorsocentrals; neotropical .... *atra* group
   Two strong pairs of dorsocentrals; Indo-Australian.......... *biseta* group

As only the *biseta* group enters the Australian Region, it is the only group dealt with here. If it is considered to be a subgenus the name *Tonnoiria* Malloch is available for it. The species may be divided into two subgroups, according to the development of the fronto-orbital bristles. The following are the known species of the *biseta* group :—

Subgroup *a* (three strong, subequal reclinate fronto-orbitals).
- *C. australis* sp. nov. New South Wales.
- *C. bisignata* sp. nov. North Queensland.

Subgroup *b* (three reclinate fronto-orbitals, the posterior one short and weak).
- *C. biseta* Hendel, 1913. Formosa.
- *C. puncticornis* Frey, 1928. Philippines. Possible synonym of *biseta* Hendel.
- *C. palliseta palliseta* (Malloch), 1929. Society Islands, Marquesas.
- *C. palliseta pleuralis* Curran, 1936. Solomons, New Hebrides, North Queensland.
- *C. delta* sp. nov. North Queensland.
- *C. atrifrons* Malloch, 1942. Guam.

Study of much more material is necessary to establish specific limits in this group. In the species of subgroup *b* specific differences may be quite small, though conspicuous sexual dimorphism occurs. Variations in the proportional lengths of the sections of the fourth vein do not seem to have taxonomic value.

Key to Australian Species of Czernyola

1. The three reclinate fronto-orbitals subequal 2
   Third (posterior) reclinate fronto-orbital much shorter and finer than others 3

2. Third antennal segment more tumid and prominent ventrally than on dorsal edge, thus obliquely oval in outline; wing with only a distal blackish patch and a very faint suffusion over posterior crossvein; incurved fronto-orbitals inserted distinctly mesad of line of reclinate orbitals .... *australis* nov.
   Third antennal segment almost orbicular, not prominent ventrally; wing with dark distal patch and a broad basal patch extending from apex of first vein across discal cell almost to posterior margin; incurved fronto-orbitals inserted in line with reclinate ones .... *bisignata* nov.

3. Pleura pale yellowish on lower half in male, entirely black in female; femora and tibiae extensively blackened in female, almost entirely pale in male; surstyli of male nearly trapezoid, with very convex posterior margin .... *palliseta* Malloch
   Pleura dark brown to black in both sexes; legs yellowish in both sexes with, at most, the apices of middle and hind femora brownish; surstyli subtriangular, the posterior margin almost straight .... *delta* nov.

Czernyola australis sp. nov.

(Fig. 19)

♂♀. Colour black, including the bristles. Frons with broad yellow anterior margin; face yellowish above, brown to black below; cheeks dark grey with white dusting on upper half; palpi and proboscis pale yellowish; antenna brownish-yellow, apex dark brown; arista brown. Thorax without pale markings. Legs light yellow-brown, fore coxa paler, hind femur somewhat darker brown; middle coxa dark brown on outer side. Wing greyish hyaline, with a dark grey patch on slightly less than the distal third, a much fainter cloud round distal part of discal cell and a small one in basal part of marginal cell. Halteres white with light brown stalks. Apex of abdomen and cerci pale yellowish in female.

General structure much as in *C. palliseta* and *C. delta.* Head much higher than long; cheek about one-seventh height of eye; fronto-orbitals four, all strong and subequal, the incurved second one set in a little from the line of the others; ocellars nearly as long as fronto-orbitals, postverticals a little shorter; antenna with third segment oval, the ventral part of the distal edge somewhat prominent; arista as in *C. delta*, but the hairs more uniform.

Thoracic chaetotaxy as in *C. delta*; scutellum entirely black-dusted. Wing with ultimate section of fourth vein three times as long as penultimate section or a little longer, the latter equal to ultimate section of fifth vein; fifth vein stopping well before wing margin.

Dimensions : total length, ♂ 3·2 mm., ♀ 2·9 mm.; length of thorax, ♂ 1·2 mm., ♀ 1·1 mm.; length of wing, ♂ 2·8 mm., ♀ 2·7 mm.

Distribution : New South Wales—Central Coast and Tableland. Deep Creek, Narrabeen, near Sydney, November 25, 1956 (holotype ♂), W. W. Wirth. Katoomba, Blue Mountains, October 30, 1958 (paratype ♀), G. H. Hardy.

Katoomba, where the paratype was collected, is at an elevation of over 3,000 feet and has a cool climate with some winter snow. This is interesting, as the other species of *Czernyola* are only recorded from the tropics.

Location of types : holotype in United States National Museum, paratype in Australian Museum.

Czernyola bisignata, sp. nov.

♂♀. Colour black; bristles yellowish brown in male, black in female. Head in female coloured as in *C. australis*, except that the frons is dark brown, not yellow, on anterior margin; in male, frons broadly yellow on anterior margin, face and cheeks whitish, third antennal segment pale yellowish, with brown mark at base of arista. Legs yellowish, apices of femora somewhat darker. Wing with a dark grey patch occupying distal third, and another quite broad one from apex of first vein across discal cell almost to posterior margin.

General structure very similar to other Australian species. Head not much higher than long; cheek one-seventh to one-ninth as high as eye; three subequal reclinate fronto-orbitals, the incurved fronto-orbital almost in line with them; third antennal segment almost orbicular.

Thoracic chaetotaxy as in *C. delta*, except that anterior dorsocentral in male is very weak and not half as long as posterior one, and in female but slightly shorter than posterior one. Wing with ultimate section of fourth vein nearly five times as long as penultimate section, the latter half, or slightly more than half, as long as ultimate section of fifth vein.

Dimensions : total length, ♂ 2·5 mm., ♀ 3·1 mm.; length of thorax, ♂ 1·0 mm., ♀ 1·1 mm.; length of wing, ♂ 2·2 mm., ♀ 2·5 mm.

Distribution : North Queensland. Kuranda, December 26, 1958 (holotype ♂), December 28, 1958 (paratype ♀), D. K. McAlpine.

Habitat : rain forest.

Location of types : Australian Museum.

Czernyola delta sp. nov.

(Fig. 14)

♂♀. Colour black, somewhat shining; bristles yellowish to brown in male, darker brown in female. Frons without pale anterior margin, extensively dusted anteriorly, shining on orbits and on posterior third or less; face and cheeks pale yellowish to mid-grey, dusted, upper part of cheek silver-dusted; antennae of male pale yellow, the first and second segments usually slightly darker than third (brown in one specimen), third segment without dark mark near arista; antenna of female with first and second segments deep brown, third segment dull yellowish with a brownish spot surrounding base of arista; proboscis and palpi pale yellowish. Thorax of male with yellowish area confined to a median ventral band on sternopleura extending forwards from insertion of middle coxae; thorax of female with only the extreme postero-ventral angles of sternopleura between bases of middle coxae slightly yellowish. Legs yellowish, apices of middle and hind femora sometimes slightly darker. Wings hyaline with a greyish tinge and a more distinct greyish cloud on distal half, which is obsolete towards posterior margin. Halteres pale yellowish. Abdomen black.

Head structurally as figured for *C. palliseta pleuralis*, with four fronto-orbitals, the anterior three long and strong, the second incurved, the posterior one short and weak; third antennal segment subdiscoid; arista with short hairs not more than twice as long as its basal diameter.

Thorax with two pairs of strong subequal dorsocentrals, the anterior one well behind suture, and with a variably developed short bristle in front of it up to half its length; mesopleuron with numerous hairs posteriorly; scutellum flattened on top, with a pair of long apical bristles and two pairs of very short lateral bristles. Fore femur of male with numerous postero-ventral bristles and some shorter antero-ventral bristles near apex; middle femur of male with numerous antero-ventral and postero-ventral bristles; female without well developed femoral bristles, except for some postero-ventral ones on distal part of fore femur. Second and third veins somewhat diverging apically; third and fourth veins almost parallel apically; ultimate section of fourth vein four to six times as long as penultimate section.

Male postabdomen with sixth tergite normal; sixth sternite ventral, joined to the seventh on the left side by a narrow sclerotized strip; sixth spiracles in membrane below edges of sixth tergite; seventh sternite broadly fused with eighth on left side, extending narrowly around ventral surface; seventh left spiracle situated in edge of seventh sternite near its junction with sixth sternite. Surstyli triangular, acute, posterior margin straight to slightly concave, the inner surface with a broad blade occupying most of its length and toothed near apex. Ninth sternite consisting of distinct left and right pieces, joined posteriorly by a weakly sclerotized band. Phallobase sclerotized, with a pair of well developed parameres, produced into a short thorn-like spinus ditillatorius posteriorly and into a slightly projecting angle on each side ventrally. Aedeagus moderately elongate, largely membranous, not coiled, but the apex asymmetrically folded; basal part with a pair of broad, weakly pigmented skeletal strips, distal to these another strip which connects to the sclerotized apical part. Cerci about as long as surstyli, rather broad, setulose.

Dimensions : total length, ♂ 2·1-2·2 mm., ♀ 2·7-3·5 mm.; length of thorax, ♂ 0·8-1·1 mm., ♀ 1·0-1·1 mm.; length of wing, ♂ 1·8-2·4 mm., ♀ 2·4-2·8 mm.

Distribution : North Queensland—Cairns District. Lake Placid (or Barron Waters), May 26, 1958 (holotype ♂, paratypes, 2 ♂, 1 ♀), May 24, 1958 (paratype ♀). Kuranda, May 17. 1958 (paratype ♂). Collected by D. K. McAlpine.

Habitat : on shrubs at edge of rain forest. This species was taken, together with *C. palliseta pleuralis*, at Lake Placid. Both species invariably settled on the undersides of the leaves.

Location of types : Australian Museum.

Differs from *C. atrifrons* in its entirely dark thorax, from *C. palliseta* in the pale-coloured legs of female and in the entirely dark pleura of male, and from *C. biseta* in the absence of a brown ring on the hind tibiae of male and in the pale legs of the female.

Czernyola palliseta (Malloch) comb. nov.

Tonnoiria palliseta Malloch, 1929, 1932.

This species has a wide range through the tropics of the southern Pacific Ocean. Two races are distinguished at present which may represent distinct species, though it is difficult to find clear-cut differences in the males. The eastern race occurs in the Marquesas and Society Islands and the western one in the New Hebrides, Solomon Islands and North Queensland.

Czernyola palliseta palliseta (Malloch)

This form needs further study to establish its status. Only one male and one female from Tahiti are available to the author. These were examined by Malloch, and the male bears his identification label. Malloch (1932) recorded, but did not describe, the female.

♂. Very like the next race, but average size greater. Surstyli of very similar form to those of *C. p. pleuralis*. Anterior margin of frons very broadly yellow. Fronto-orbitals as in the next race.

♀. Differs from the next race in the following points : Frons with very broad yellowish brown anterior margin; antennae uniformly black. Fore coxae partly brownish. Size larger.

Dimensions : total length, ♂ 2·7 mm. (3·25 mm. in holotype), ♀ 3·8 mm.; length of thorax ♂ 1·1 mm., ♀ 1·5 mm.; length of wing, ♂ 2·7 mm., ♀ 3·4 mm.

Distribution : Society Islands and Marquesas.

Location of material : holotype and material examined by author in United States National Museum.

Malloch overlooked the small posterior fronto-orbital bristle, but on my request Dr. C. W. Sabrosky has confirmed its presence in the type and states that it is also present in *C. atrifrons* Malloch.

Czernyola palliseta pleuralis Curran, status nov.

(Figs. 17, 18, 24, 25)

Czernyola pleuralis Curran, 1936.

Very similar to *C. delta* in colour and structure, but the following characters are noteworthy :—

♂. Anterior margin of frons more or less yellowish, at least in centre; a brown mark on third antennal segment at base of arista; first and second segments not darker than third; palpi pale yellowish. Thorax black, with sternopleuron, hypopleuron and lower margins of mesopleuron and pteropleuron pale yellowish; legs yellowish with at most the knees brownish.

Postabdomen structurally similar to that of *C. delta*; the surstyli, when viewed directly from side, with strongly convex posterior margin, and thus almost trapezoid in outline.

♀. Frons often without yellowish anterior margin; face greyish; cheeks brown to black, silvery dusted above; distal margin of third antennal segment blackened, basal segments not darkened; palpi dark brown to black. Thorax almost entirely dark brown to black, only posteromedian angles of sternopleura between middle coxae yellowish; legs with all coxae and tarsi pale yellowish, femora and tibiae black except at bases and apices.

Dimensions : total length, ♂ 2·0-2·7 mm., ♀ 2·7-3·2 mm.; length of thorax, ♂ 0·9-1·1 mm., ♀ 1·1-1·2 mm.; length of wing, ♂ 1·8-2·4 mm., ♀ 2·4-2·8 mm.

Distribution : Solomon Islands, New Hebrides and North Queensland. Santa Catalina Island, Solomon Group (holotype ♂). Guadalcanal, Solomon Group, 1944 (♂), C. O. Berg. Little Florida Island, Solomon Group, March, 1945 (♂, ♀), G. E. Bohart. Second Channel, Espiritu Santo, New Hebrides, July, 1944 (♂), Jean Laffoon. Lake Placid, near Cairns, May 24 and 26, 1958 (32 ♂, 9 ♀), D. K. McAlpine.

Habitat : on shrubs at edge of rain forest.

Location of material : holotype in Museum of California Academy of Sciences, Australian specimens in Australian Museum, other material in United States National Museum.

The male may be distinguished from other species of the *biseta* group by the pale lower parts of the pleura. One of the males from Lake Placid has dark pleura, as in the female. The female differs from other species of this group in having the tibiae and femora, but not the coxae, black.

Genus Clusiodes Coquillett

This genus is easily recognized from the characters given in the key. Though widely distributed, it is not previously recorded from Australia.

The three species here described are closely related to one another, but do not seem to have close allies among species from other regions. For this reason, the first species is described in some detail and the others are more briefly compared with it.

Melander and Argo follow Malloch in recognizing three subgenera of *Clusiodes* : *Clusiaria* Malloch, which has no presutural dorsocentral and but two postsutural dorsocentrals; and two subgenera which have three pairs of long dorsocentrals, one of them in front of the suture. Of the two latter, *Columbiella* Malloch differs from *Clusiodes* sensu stricto in the absence of post-vertical bristles. Czerny (1928) has used *Clusiaria* as a full genus, but has not been followed by most authors. The Australian species have three pairs of long dorsocentrals, the foremost varying from slightly in front of to slightly behind the suture, and are thus intermediate between the subgenera *Clusiaria* and *Clusiodes*. The peculiar development of the vibrissae and associated melanization of the face in the male of *C. gladiator* would seem to ally this species to the Nearctic *C. melanostoma* (Loew), but in the former the vibrissae of both sexes are longer. Moreover, *C. melanostoma* has dorsocentral bristles typical of the subgenus *Clusiaria*. The only species of the genus previously recorded from the Indo-Australian Region are *C. aberrans* Frey (1928), from the Philippines, and *C. formosana* Hennig (1938a), from Formosa. These species differ from all others in having long, dense hairs on the arista, which give it a thickened appearance. The Australian species have much longer aristal hairs than the Holarctic ones, but the hairs are not crowded or appressed, so that the arista does not appear thickened. They also differ from *C. aberrans* in having six, instead of four, scutellar bristles and three, instead of two, dorsocentrals. Unfortunately, the thoracic chaetotaxy of *C. formosana* was not described.

The terminalia of an Australian species are shown in Fig. 17, and their structure is discussed in the section on terminalia. They agree with those of the two European species of *Clusiodes* described by Séguy (1934) and Hennig (1938a) in having one pair of parameres, an elongate phallobase and a membranous aedeagus which is not spirally coiled. Further information is required concerning the disposition of the sixth to eighth sternites in the European forms.

Key to Australian Species of Clusiodes

1. General colour black; sternopleuron, hypopleuron, antennae and most of legs pale yellowish; fore tibiae and tarsi black; wings unmarked .... *clara* nov.
   Head and thorax predominantly yellowish with few dark markings; wings with dark costal mark 2
2. Mesonotum with a black patch on each side that extends from the dorsocentrals to the wing base; a blackish spot present on each side of occiput; legs, except the fore tarsi, entirely yellowish; face in both sexes with a small black median mark only .... *megaspilos* nov.
   Mesonotum with a comparatively narrow longitudinal stripe between dorsocentrals and wing base; no dark occipital marks; at least the hind femora blackened distally; face blackened in male, at least near bases of vibrissae, but not at all blackened in female 3
3. Anterior dorsocentral scarcely shorter than others, at or very slightly in front of suture; black mesonotal stripe approximated to dorsocentrals, well removed from supra-alar; dark costal mark not reaching basally to first vein; only the hind femora with dark markings; third antennal segment with dark spot at apex .. *gladiator* nov.
   Anterior dorsocentral not more than three-quarters as long as second, slightly behind suture; black mesonotal stripe well removed from dorsocentrals, enclosing the supra-alar; dark costal mark reaching almost to base; all femora with dark markings; third antennal segment without dark spot .... *arguta* nov.

Clusiodes gladiator sp. nov.

(Figs. 8, 9, 23)

♂♀. Colour light brownish-yellow, somewhat shining; bristles and most hairs black. Ocellar spot black; face and anterior part of cheek dark brown to black in male only; arista and apex of third antennal segment black. Mesonotum with a blackish longitudinal band on either side between dorsocentral and supra-alar bristles, much closer to the former, beginning shortly behind suture and extending on to lateral metanotal sclerite posteriorly; pleura with a brown

band beginning on humeral callus and almost reaching haltere. Apices of hind femora, and often also the bases and apices of hind or all tibiae, brown; legs otherwise entirely yellowish. Wings hyaline with a dark costal band on apical half, extending around apex of wing to just beyond fourth vein. Abdomen brown, the distal parts of second to fifth tergites usually darker.

Head slightly higher than long; frons wider than long and about half as wide as head; lunule covered; cheek about one-sixth as high as eye; eyes large and rounded; ocellars and postverticals well developed, the former longer; three fronto-orbitals, the middle one long and strong, the others weak and not more than half as long; interfrontals moderately long, convergent or crossed; vibrissae of male sometimes exceptionally developed, up to one-and-a-half times as long as head, sigmoidally curved or merely incurved; vibrissae of female strong, incurved, about as long as head; a series of cheek hairs behind vibrissa; third antennal segment almost orbicular; arista with numerous but not dense hairs, the longest ones nearly half as long as width of third antennal segment.

Thorax with the following bristles : sternopleural; mesopleural; humeral; two notopleurals; supra-alar; postalar; a smaller posterior intra-alar; three strong, subequal dorsocentrals, the anterior one situated at the suture; no acrostichals; six marginal and no discal scutellars, the apical pair longest, other two pairs subequal; two short, fine propleural hairs. Fore and middle femora with postero-ventral series of bristles and sometimes all femora with weaker antero-ventral bristles; fore femora with postero-dorsal bristles also; all tibiae with paired preapical dorsal bristles, shortest on fore tibiae. Penultimate section of fourth vein about one-quarter the length of ultimate section and nearly as long as ultimate section of fifth vein.

Dimensions : total length, ♂ 3·0-3·7 mm., ♀ 3·1-4·2 mm.; length of thorax, ♂ 1·2-1·7 mm., ♀ 1·2-1·9 mm.; length of wing, ♂ 2·9-3·8 mm., ♀ 3·0-3·9 mm.

Distribution : New South Wales—Coast and Tablelands; Queensland—Tablelands in north and south. N.S.W. : National Park, south of Sydney, December 31, 1955 (holotype ♂). April 28, 1956 (paratype ♀); Otford, Illawarra District, January 26, 1959 (paratypes, 2 ♂), March 7, 1959 (paratypes, 2 ♂, 1 ♀); Wentworth Falls, Blue Mountains, February 28, 1957 (paratype ♀), April 22, 1957 (paratypes, 3 ♂), November 20, 1958 (paratypes, 1 ♂, 1 ♀), November 29, 1958 (paratype ♀); below Govett's Leap, Blue Mountains, December 7, 1956 (paratypes, 2 ♂), September 14, 1957 (paratypes, 2 ♂); Mount Wilson, Blue Mountains, March 2, 1957 (paratype ♀), March 29, 1958 (paratypes, 2 ♂), February 7, 1959 (paratype ♂); all the above collected by D. K. McAlpine; Salisbury, near Barrington Tops, November 1-5, 1957 (paratype ♀), F. A. Perkins. Queensland : Lamington National Park, October 21, 1934 (paratype ♂), F. A. Perkins; October 26, 1957 (paratypes, 3 ♂), I. C. Yeo; Barron River, near the Crater, Atherton Tableland, January 3, 1959 (paratype ♂), D. K. McAlpine.

Habitat : in and near rain forest on banks of creeks.

Location of types : holotype and 19 paratypes in Australian Museum, five paratypes (Lamington National Park and Salisbury) in Entomology Department, University of Queensland

Clusiodes arguta sp. nov.

♂♀. Colour similar to that of *C. gladiator*; third antennal segment without dark apex; black mesonotal bands removed from dorsocentrals. enclosing the supra-alar bristle; pleura band paler than in *C. gladiator*; apices of all femora and tibiae black to brown; fore tarsi brown in female only; wings with dark costal band extending almost to base.

Head structurally as described for *C. gladiator*, except that the vibrissae are not as long as the head in either sex.

Thoracic chaetotaxy as in *C. gladiator*, except that the anterior dorsocentral is not more than three-quarters as long as the second and is situated slightly behind the suture; scutellum with a pair of small setulae between apical bristles in female. Chaetotaxy of legs and wing venation also as in *C. gladiator*.

Dimension : total length, ♂ 3·4 mm., ♀ 3·8-4·1 mm.; length of thorax, ♂ 1·5 mm., ♀ 1·5-1·7 mm.; length of wing, ♂ 3·3 mm., ♀ 3·3-3·8 mm.

Distribution : New South Wales—Blue Mountains. Wentworth Falls, February 28, 1957 (holotype ♂), February 2, 1957 (paratypes, 3 ♀), November 29, 1958 (paratype ♀), D. K. McAlpine.

Habitat : in and near rain forest on banks of creeks.

Location of types : Australian Museum.

Clusiodes megaspilos sp. nov.

♂♀. Colour similar to that of *C. gladiator*. Face with a small black median mark in both sexes; occiput with a large blackish spot on each side extending from the dorsocentrals to the wing base; upper margin of mesopleuron brown in male, upper half blackish in female; pteropleuron only darkened posteriorly; metapleuron with a dark brown spot. Fore tarsi blackish, the legs otherwise unmarked. Wings marked as in *C. gladiator*, but the costal mark not as dark and less extensive.

Head structurally as in *C. gladiator*, but the vibrissae not as long as head.

Thoracic chaetotaxy as in *C. gladiator*, the first pair of dorsocentrals slightly in front of suture. Both preapical bristles on fore tibia and the posterior one on hind tibia very small. Venation as in *C. gladiator*.

Dimensions : total length, ♂ 2·4-2·8 mm., ♀ 2·7-3·5 mm.; length of thorax, ♂ 1·0-1·2 mm., ♀ 1·2-1·3 mm.; length of wing, ♂ 2·3-2·9 mm., ♀ 2·5-3·0 mm.

Distribution : New South Wales and Southern Queensland—Tablelands. New South Wales : Wentworth Falls, Blue Mountains, February 2, 1957 (holotype ♂, paratypes, 1 ♂, 3 ♀), February 28, 1957 (paratypes, 2 ♂, 1 ♀), November 5, 1957 (paratype ♂), D. K. McAlpine; Mount Wilson, Blue Mountains, February 7, 1959 (paratype ♂), D. K. McAlpine. Queensland : Lamington National Park, October 26, 1957 (paratype ♂), I. C. Yeo.

Habitat : in and near rain forest on banks of creeks.

Location of types : specimens from Wentworth Falls and Mount Wilson in Australian Museum; specimen from Lamington National Park in Entomology Department, University of Queensland.

Clusiodes clara sp. nov.

♀. Colour black, somewhat shining; bristles yellowish to black. Labella of proboscis and antennae brownish-yellow. Thorax with sternopleuron, hypopleuron and lower margin of mesopleuron pale yellowish; a black dot on sternopleuron just above middle coxa. Legs pale yellowish; fore tibiae and tarsi black; middle and hind tibiae and apices of all femora pale brown. Wings hyaline, without dark markings; veins brown. Halteres whitish, with pale brown stalks. Abdomen without pale markings.

Structure and chaetotaxy very similar to that of *C. gladiator*. Head collapsed in type, so that proportions cannot be stated; foremost fronto-orbital shorter than in *C. gladiator*; vibrissae long, incurved; arista with longest hairs distinctly less than half as long as width of third antennal segment, that is, slightly shorter than in the other Australian species.

Thorax with three pairs of dorsocentrals, the first slightly shorter than second and situated very slightly in front of suture; scutellum with basal pair of bristles minute, about one-third as long as intermediate pair, which is half as long as the apical pair; disc of scutellum with weak longitudinal wrinkles; apical hairs absent. Fore femur with weak postero-ventral and postero-dorsal bristles. Penultimate section of fourth vein less than one-quarter as long as ultimate section of fourth and about two-thirds as long as ultimate section of fifth vein.

Dimensions : total length, 2·3 mm.; length of thorax, 1·0 mm.; length of wing, 2·5 mm.

Distribution : Queensland—north-east. Silkwood, near Innisfail, May 25, 1958 (holotype ♀), D. K. McAlpine.

Habitat : rain forest on bank of creek.

Location of type : Australian Museum.

Genus **Parahendelia** nov.

Frons and face very broad; lunule covered; ocellars and postverticals well developed; three fronto-orbitals, all reclinate; interfrontals well developed, widely spaced, inserted near ptilinal suture; antennae widely separated and approximated to the eyes, especially in male, second segment subcylindrical, very elongate in male, as long as third segment in female, arista filiform.

Thorax with two pairs of dorsocentrals, both behind suture; two (rarely three) pairs of short lateral scutellars and a pair of long apical ones; acrostichal and presutural bristles absent. All tibiae with paired preapical dorsal bristles; tarsi slender, cylindrical. Wings as in *Clusiodes*.

Type species, *P. latifrons* sp. nov.

This genus is most closely related to *Clusiodes* and *Hendelia*. The latter genus contains only one known species, *H. beckeri* Czerny (synonym *H. nigripalpis* Czerny) from the Palearctic Region. The new genus differs from *Clusiodes* and resembles *Hendelia* in the broad head, widely separated antennae and insertion of interfrontals near ptilinal suture. It differs from *Hendelia* in the slender tarsi, filiform arista, larger, widely spaced interfrontals, and in other characters of chaetotaxy such as the presence of postverticals and the numbers of fronto-orbitals, dorsocentrals and scutellars. The outstanding difference between *Parahendelia* and all other genera of Clusiidae lies in the elongate second antennal segment.

Key to Species of Parahendelia

1. Head yellowish; male with second antennal segment about as long as head, slender, subcylindrical .... *latifrons* nov.
   Head predominantly black; male with second antennal segment shorter than head, conical .... *nigriceps* nov.

Parahendelia latifrons sp. nov.

(Figs. 10, 11, 15)

♂. General colour light yellow-brown, shining; bristles black. Head with ocellar spot, arista and dorsal margin of third antennal segment black; lower margin of palpi brown to black. Thorax with prosternum and pleura (except propleuron, lower part of hypopleuron and often a patch on sternopleuron in front of coxa) black; mesonotum with a postsutural black streak on each side between dorsocentral and supra-alar bristles, closer to the former. Fore tibia brown to black, except at base; fore tarsus brown to black on basal part of metatarsus and on the two distal segments; legs otherwise unmarked. Wings hyaline, with a blackish costal band on distal half, extending to just beyond fourth vein and sometimes extending indistinctly to fork of second and third veins.

Head about twice as wide as high, and nearly one and a half times as high as long; frons about three-fifths as wide as head; cheek tumid, about one-third as high as eye; vibrissal angle absent; face sclerotized only on upper margin; middle fronto-orbital long, posterior one about half as long, anterior one even shorter; ocellars as long as middle fronto-orbital; postverticals slightly shorter; interfrontals widely spaced, situated just above ptilinal suture and level with the anterior fronto-orbitals, slightly longer than posterior fronto-orbitals; in the type specimen an additional longer interfrontal bristle present on left side only, just below level of posterior fronto-orbital; vibrissae strong, about one and a half times as long as head, incurved, asymmetrical; cheek hairs few and fine; palpi short and broad; antennae porrect, about twice as long as head; first segment short and rounded; second segment as long as head or slightly longer; third segment shorter, elongate oval, densely pubescent at apex; arista slightly longer than third segment, with rather dense short hairs, the longest ones slightly longer than basal diameter.

Thorax rather broad; mesoscutum with short, fine, rather dense hairs anteriorly and sparser hairs posteriorly, the black markings almost devoid of hairs; scutellum devoid of hairs, slightly rugose; two small propleural setulae present; mesopleuron with some short hairs on posterior half in addition to the long bristle. Fore and middle femora with series of strong postero-ventral and shorter antero-ventral bristles. Wing with ultimate section of fourth vein about four to five times as long as penultimate section and about twice as long as ultimate section of fifth vein.

Cerci not prominent.

♀. Differs from male in the following characters:—

Palpi, prosternum, sternopleuron (except extreme ventral part) and most of hypopleuron, light yellow-brown. Fore tibia, except extreme base, and fore tarsus black; apex of fore femur brown. Wing with blackish costal band darker and extending basally to fork of second and third veins.

Head less broad than in male and antennae less widely separated; cheek slightly less than one-quarter as high as eye; vibrissae shorter than head, incurved; antennae shorter than head, with second and third segments subequal and both much shorter than in male.

Femoral bristles undeveloped, except some short postero-ventral ones on fore legs.

Dimensions : total length, ♂ 2·6-3·0 mm., ♀ 3·8 mm.; length of thorax, ♂ 1·3-1·4 mm., ♀ 1·5 mm.; length of wing, ♂ 3·1-3·2 mm., ♀ 3·6 mm.

Distribution : New South Wales—Blue Mountains. Wentworth Falls, November 5, 1957 (holotype ♂), November 20, 1958 (paratype ♀), D. K. McAlpine. Mount Wilson, December 11, 1959 (paratypes, 3 ♂), D. K. McAlpine.

Habitat : on ferns in rain forest.

Location of types : Australian Museum.

The male is easily recognizable in the field by means of the length and position of the antennae, which may be vibrated in a similar manner to those of many Hymenoptera.

Parahendelia nigriceps sp. nov.

(Fig. 16)

♂. General colour shining black. Head with postgena, some markings on upper occiput, and mouth-parts, yellowish-brown; antenna dull fulvous, upper margin and apex of third segment and arista black. Thorax with mesonotum and postnotum brownish-yellow, the former with postsutural black marks as in *P. latifrons*; humeral calli brown-black. Legs brownish-yellow; fore tibia except base, and first, fourth and fifth segments of fore tarsus blackish; legs otherwise unmarked. Wings marked as in *Clusiodes gladiator*, the dark costal mark very distinct on distal half of wing only, but extending basally as an ill-defined greyish cloud. Abdomen brownish basally.

General structure similar to that of *P. latifrons*; chaetotaxy as described for that species. Head about twice as wide as high and about 1·2 times as high as long; cheek at middle nearly one-fifth as high as eye; vibrissae about as long as antennae (excluding arista), asymmetrical as in male of *P. latifrons*. Antennae about one and a quarter times as long as head; second segment stout, conical; third segment broad basally, tapering apically, fully as long as second segment; arista nearly three-quarters as long as rest of antenna, inserted at middle of upper margin of third segment, its longest hairs nearly twice as long as its basal diameter.

Thorax and appendages structurally as described for *P. latifrons*.

Dimensions : total length, 2·5 mm.; length of thorax, 1·2 mm.; length of wing, 2·6 mm.

Distribution : New South Wales—Blue Mountains. Mount Wilson, February 7, 1959 (holotype ♂), D. K. McAlpine.

Habitat : rain forest, elevation 3,000 feet.

Location of type : Australian Museum.

The smaller size, black head, narrower cheek and shorter, stouter antennae distinguish this from the male of the type species. The first two characters, at least, should also be available for separating the females.

Genus **Allometopon** Kertész, 1906

Fronto-orbitals all reclinate; a pair of interfrontals situated low down near ptilinal suture; ocellars present; postverticals absent or small; palpi slender; third antennal segment wider than long; preapical tibial bristles absent.

Type species, *A. fumipenne* Kertész (New Guinea).

Lamb (1914) described *Allometopon flavum* from the Seychelles, and Frey (1928) described two species from the Philippines which he doubtfully referred to this genus. These three species show important differences from the type which might be considered generic by some. The Australian species described below are more closely related to the type species, although the first of them is the only one in which the crossveins of the wing are very close together.

The genus is in the unsatisfactory state of having each of its six species known from a single specimen. The specific limits are, therefore, a matter of conjecture, but the characters used herein are comparable with those employed in other genera. As no previous attempt has been made to tabulate the specific characters, I give below a key to the described species based on the published descriptions.

Key to Species of Allometopon

1. Four fronto-orbitals; interfrontals as long as foremost fronto-orbital; small postverticals present; Seychelles .... *flavum* Lamb

   Two or three fronto-orbitals; interfrontals very short; postverticals usually absent .. 2

2. Three fronto-orbitals 3

   Two fronto-orbitals 5

3. Ultimate section of fourth vein five times as long as penultimate section; postverticals and acrostichals absent; Australia .... *perkinsi* nov.

   Ultimate section of fourth vein three times as long as penultimate section 4

4. Prescutellar acrostichals and small postverticals present; pale median area of mesoscutum containing two dark stripes posteriorly; Australia...... *striatum* nov.

   Acrostichals and postverticals absent; mesoscutum without dark stripes in pale median area; New Guinea .... *fumipenne* Kertész

5. Thorax with dark median stripe only, otherwise yellowish; (arista missing in type); Philippines .... *palpale* Frey

   Thorax with black median stripe and a black lateral mark connected with the black mesopleuron; pteropleuron, postnotum and scutellum also black; arista thickened, with long dense hairs; Philippines .... *hirsutisetum* Frey

Allometopon perkinsi sp. nov.

(Figs. 20-22)

♂. Head pale yellowish; upper part of occiput black; posterior part of frons greyish; ocellar spot black; third antennal segment brown on dorsal extremity. Thorax and legs very pale yellow, the latter unmarked; mesonotum brownish, broadly margined anteriorly, laterally and around scutellum with brown-black, the dark colour extending on to metanotum (metapleura or pleurotergite of some writers) and postnotum; pleura proper without markings. Bristles and hairs of head and thorax mostly yellowish-brown. Wings hyaline, with a greyish cloud on the anterior apical part. Abdomen black, with a yellowish-brown median dorsal stripe anteriorly; hairs black.

Head nearly as long as high; frons nearly two-fifths as wide as head; cheek in middle about one-fifth as high as eye, narrower anteriorly; postverticals absent; ocellars well developed; three fronto-orbitals, the first slightly shorter than, and the second slightly longer than, the third; interfrontals very short; vibrissae slightly longer than antennae (excluding arista); cheek hairs rather long, spreading horizontally; arista with longest hairs about as long as its basal diameter.

Thorax mostly shining and undusted, the scutellum finely pubescent on disc and sides; two strong dorsocentrals far behind suture, the posterior one longer; no acrostichals; a long supra-alar and postalar; a short weak posterior intra-alar; three pairs of scutellars, the apical pair much the longest; presuturals absent ; one minute propleural setula; mesopleuron with fine pale setulae in addition to the strong bristle. Fore and middle femora with well developed series of postero-ventral bristles. Wings with ultimate section of fourth vein approximately five times as long as penultimate section.

Abdomen with surstyli broad, truncate, setulose on the distal posterior angle.

Dimensions : total length, 3·0 mm.; length of thorax, 1·3 mm.; length of wing, 3·0 mm.

Distribution : Queensland—south-east. Lamington National Park, October 29, 1955, F. A. Perkins (holotype ♂).

Location of type : Queensland Museum.

Allometopon striatum sp. nov.

♀. General colouring as described for *A. perkinsi*; bristles and some hairs black. Frons without greyish area posteriorly; occiput with a dark brown patch on each side of upper part, the two patches joined by a pale brownish area just above the occipital foramen; third antennal segment black on dorsal third. Scutellum dark brown; mesoscutum with a pair of dark brown bands posteriorly between the dorsocentrals and acrostichals. Wings with greyish cloud, as in *A. perkinsi.* Abdomen with second to fifth tergites dark brown, the fourth and fifth paler laterally; the more distal tergites, cerci and sternites pale yellowish.

Head structurally similar to that of *A. perkinsi*, but frons one-third the width of head, cheek near middle about one-seventh height of eye, and the prelabrum much more prominent (perhaps retracted in type of *perkinsi*); postverticals represented by fine hairs about half as long as ocellars; three fronto-orbitals, the first shorter than the other two, which are subequal, the second not much closer to the first than to the third; interfrontals very short and close together; arista as long as head, the longest hairs slightly longer than its basal diameter.

Thoracic chaetotaxy as described for *A. perkinsi*, but a pair of prescutellar acrostichals present, nearly half as long as posterior dorsocentrals. Fore femur with weak postero-ventral bristles on distal part. Wings with penultimate section of fourth vein approximately one-third as long as ultimate section of fourth and equal to ultimate section of fifth vein; sixth vein extending distinctly to three-quarters of the distance from anal cell to wing margin.

Abdomen with terminal segments short, largely retractile; cerci short, slender, haired.

Dimensions : total length, 3·0 mm.; length of thorax, 1·1 mm.; length of wing, 3·0 mm.

Distribution : Queensland—north-east. Kuranda, May 19, 1958 (holotype ♀), D. K. McAlpine.

Habitat : rain forest.

Location of type : Australian Museum.

Acknowledgements

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EXPLANATION OF FIGURES

1. *Tetrameringia ustulata* sp. nov. Lateral aspect of head of holotype.
2. *Heteromeringia hardyi* sp. nov. Lateral aspect of antenna of paratype.
3. *H. laticornis* sp. nov. Lateral aspect of antenna of holotype.

3A. *H. laticornis*. Outer aspect of right surstylus of holotype.

4. *H. pulla* sp. nov. Lateral aspect of head of holotype.
5. *Tetrameringia ustulata* sp. nov. Wing of paratype.
6. *Heteromeringia pulla* sp. nov. Wing of holotype.
7. *H. norrisi* sp. nov. Dorsal aspect of posterior respiratory horns, puparium of holotype.
8. *Clusiodes gladiator* sp. nov. Wing of holotype.
9. *C. gladiator*. Lateral aspect of head of holotype male.
10. *Parahendelia latifrons* sp. nov. Lateral aspect of head of holotype male.
11. *P. latifrons*. Anterior aspect of head of holotype.
12. Larva of undetermined clusiid from Mount Wilson, dorsal aspect.
13. Dorsal aspect of posterior respiratory horns of above.
14. *Czernyola delta* sp. nov. Left lateral aspect of postabdomen of holotype male.
15. *Parahendelia latifrons* sp. nov. Lateral aspect of left antenna of paratype female.

16. *P. nigriceps* sp. nov. Lateral aspect of head of holotype male.

17. *Czernyola palliseta pleuralis* Curran. Lateral aspect of head of male specimen from Lake Placid.

18. *C. palliseta pleuralis.* Anterior aspect of head of same specimen.

19 *C. australis* sp. nov. Lateral aspect of antenna of paratype.

20. *Allometopon perkinsi* sp. nov. Lateral aspect of head of holotype.

21. *A. perkinsi.* Anterior aspect of head of holotype.

22. *A. perkinsi.* Wing of holotype.

23. *Clusiodes gladiator* sp. nov. Left lateral aspect of postabdomen of male paratype. Setulae on sixth and ninth tergites omitted.

24. *Czernyola palliseta pleuralis* Curran. Outer aspect of left surstylus of specimen from Lake Placid, same aspect as in Fig. 14.

25. *C. palliseta pleuralis.* Posterior aspect of right surstylus of same specimen.

26. *Tetrameringia ustulata* sp. nov. Right lateral aspect of postabdomen of male paratype. Internal apodeme and structures on left side indicated by broken lines. Setulae on tergites and fifth and eighth sternites omitted.

27. *Heteromeringia spinulosa* sp. nov. Left lateral aspect of postabdomen of male paratype. Setulae on tergites and fifth and ninth sternites omitted.

28. *H. australiae* Malloch. Outer aspect of left surstylus of holotype.

29. *H. hypoleuca* sp. nov. Outer aspect of right surstylus of holotype.

30. *H. norrisi* sp. nov. Inner aspect of left surstylus of paratype.

31. *H. hardyi* sp. nov. Inner aspect of left surstylus of paratype.

32. *H. laticornis* sp. nov. Aedeagus of holotype.

33. *H.* species A. Inner aspect of right surstylus.

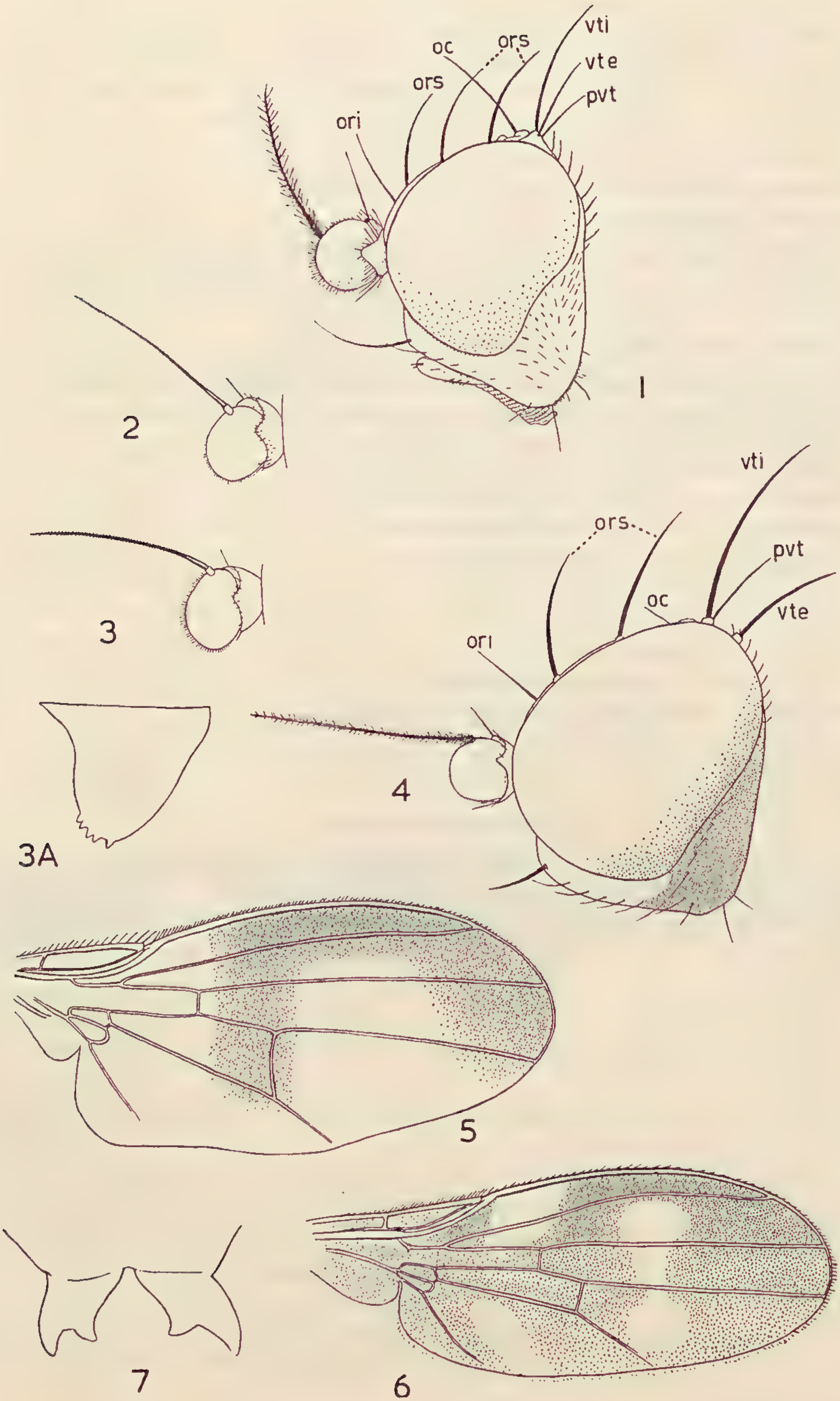
34. *H. pulla* sp. nov. Aedeagus of paratype.

35. *H. pulla.* Inner aspect of right surstylus of paratype.

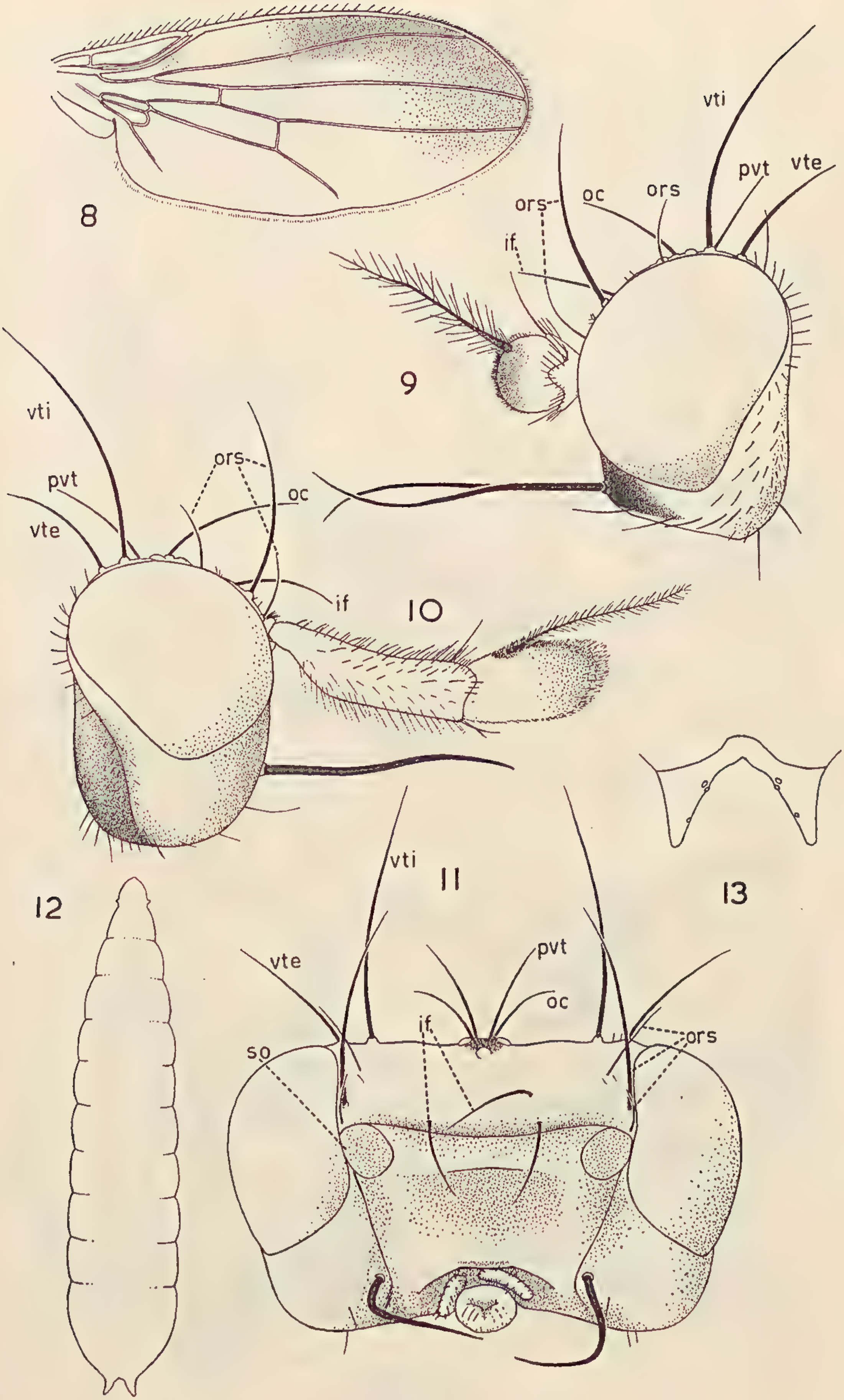
36. *H. hardyi* sp. nov. Right lateral aspect of hypandrium.

ABBREVIATIONS USED IN FIGURES

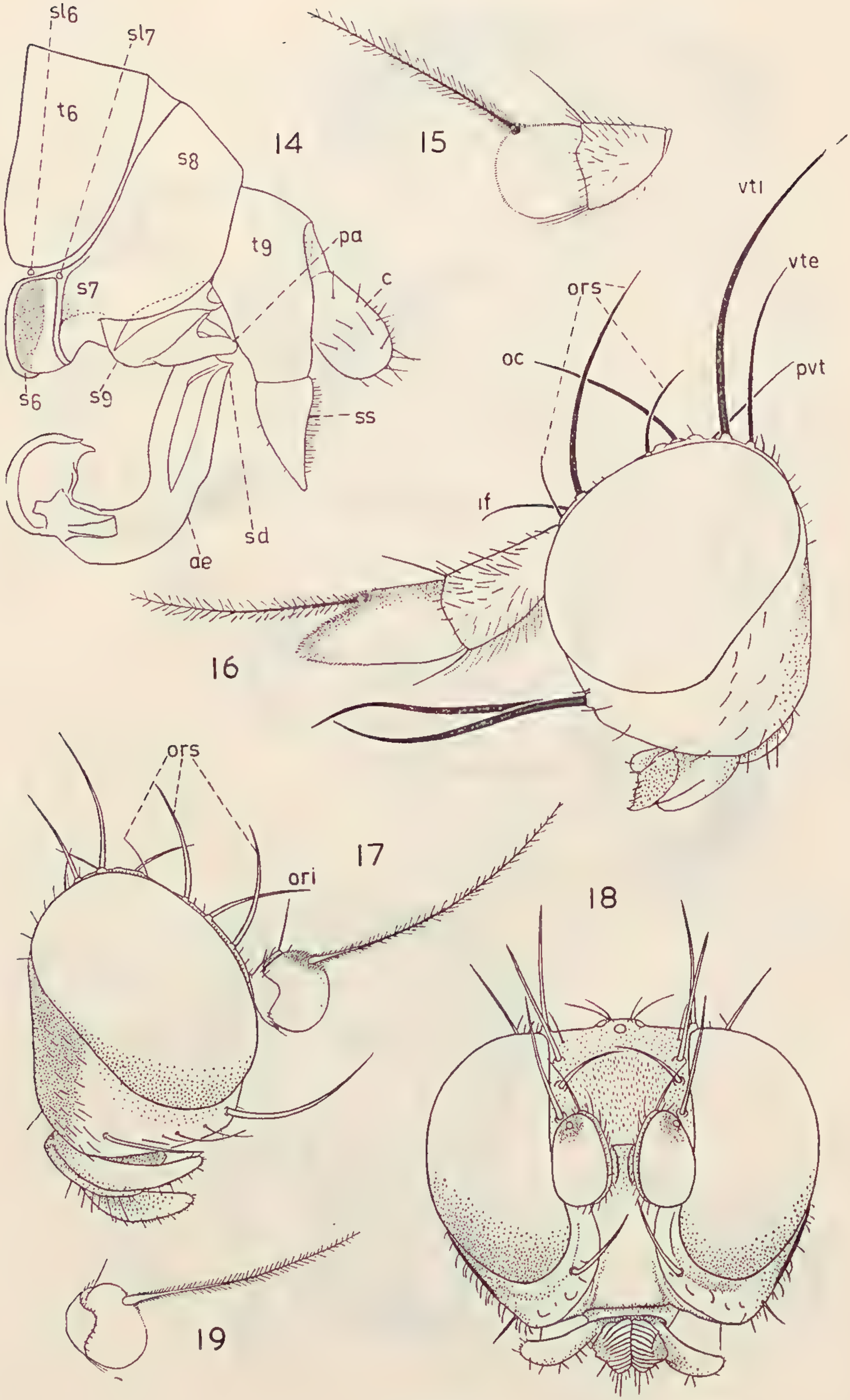
ae, aedeagus. ap, apodeme of aedeagus. b, blade of surstylus. ba, anterior branch of distal fork of aedeagus. bp, posterior branch of above. c, cerci. if, interfrontal bristles. lo, lobes of aedeagus. oc, ocellar bristles. ori, incurved fronto-orbital bristles. ors, reclinate fronto-orbital bristles. pa, parameres. pb, phallobase. pg, proctiger. pvt, postvertical bristles. s, sternite (numbered to correspond with abdominal segmentation). sd, spinus ditillatorius. sl, spiracle of left side (numbered as sternites). so, socket of antenna. sr, spiracle of right side (numbered as sternites). ss, surstyli. t, tergite (numbered as sternites). tf, terminal filaments of aedeagus. vte, outer vertical bristles. vti, inner vertical bristles.



Figs. 1–7.



Figs. 8–13.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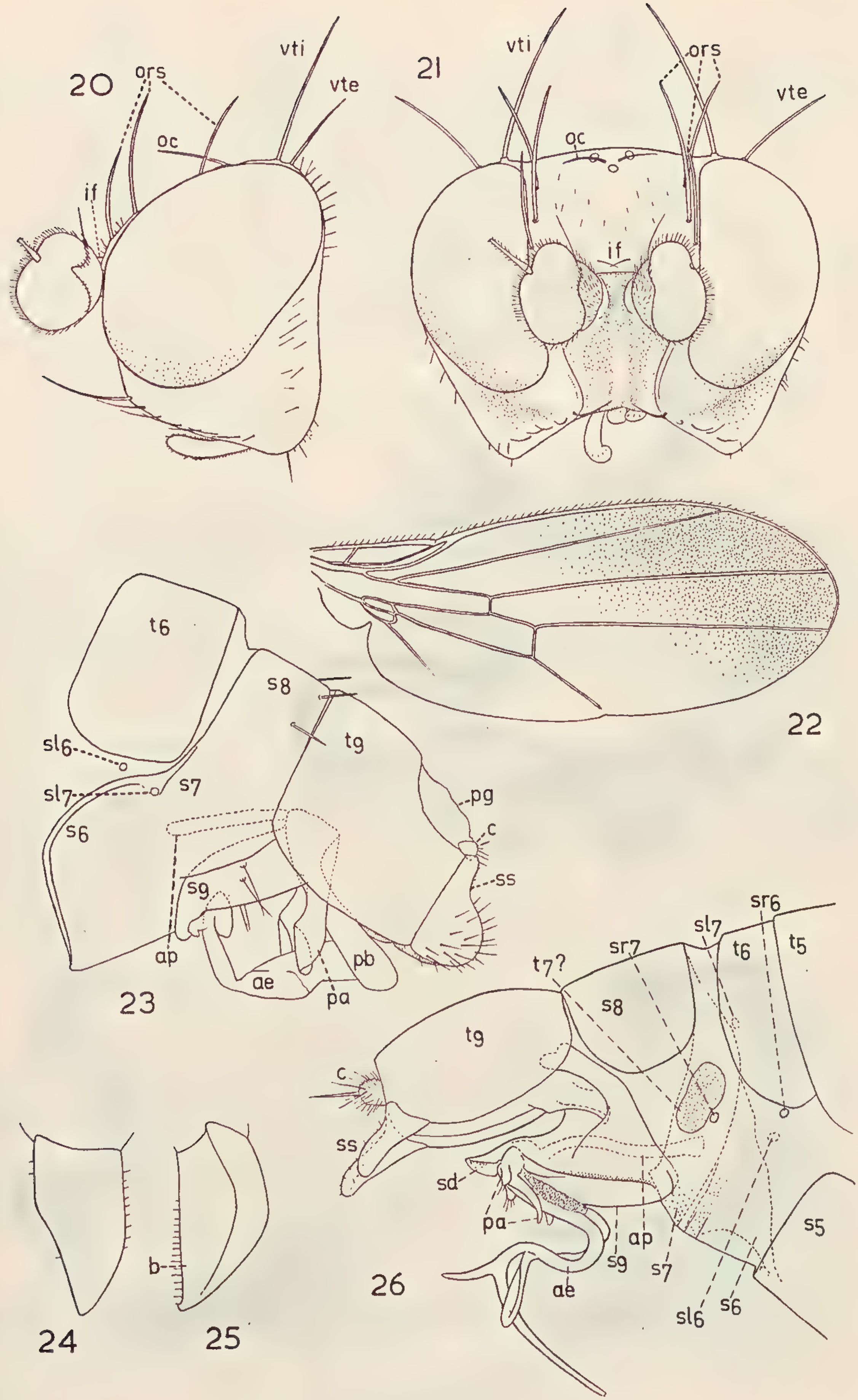
Figs. 14–19.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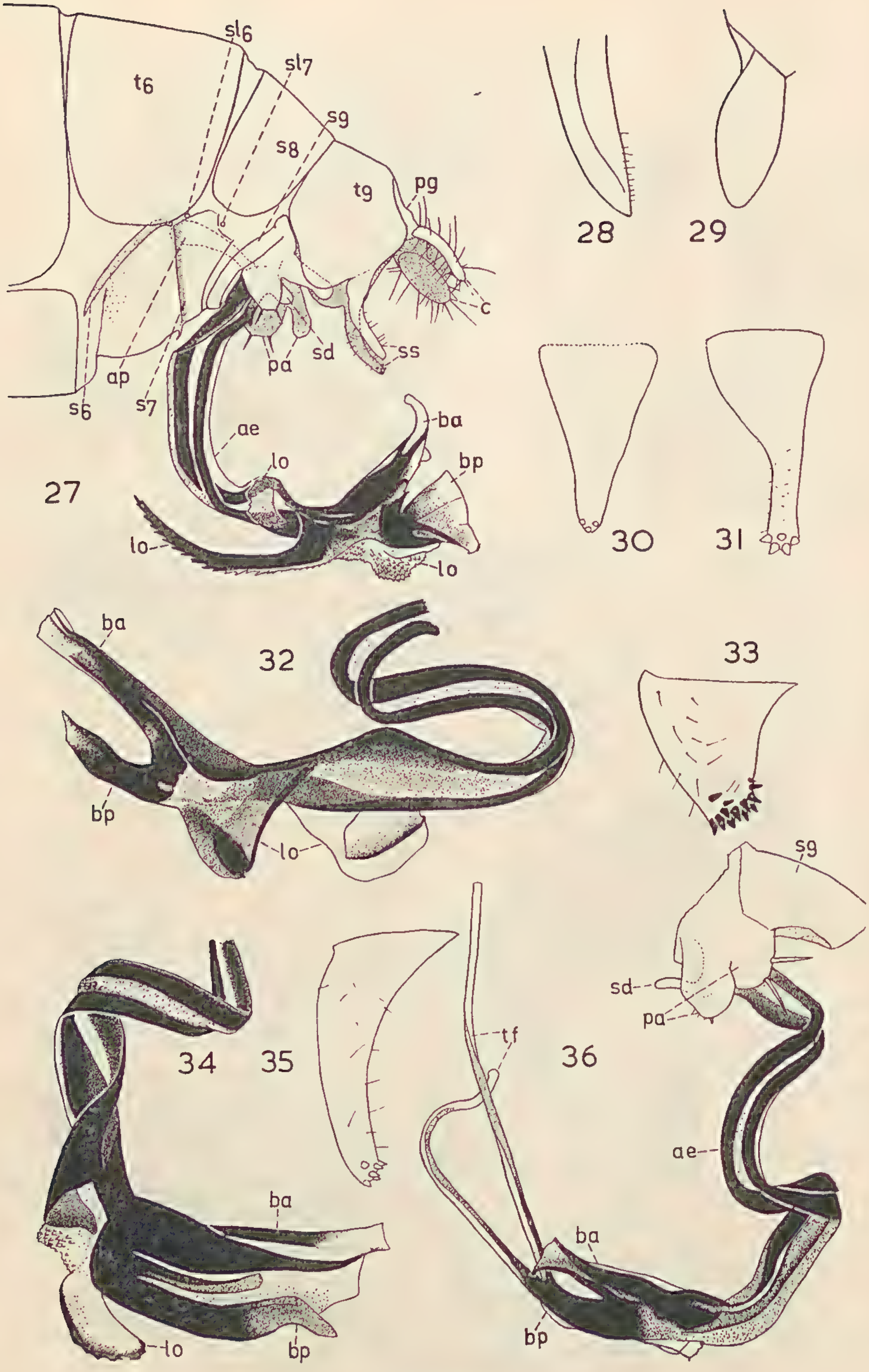
Figs. 20–26.



Figs. 27–36.

Sydney: V. C. N. Blight, Government Printer—1960

THE ECOLOGY, MORPHOLOGY, DISTRIBUTION AND SPECIATION OF A NEW SPECIES AND SUBSPECIES OF THE GENUS EGERNIA
(*Lacertilia : Scincidae*)

By Harold G. Cogger,
Australian Museum

(Figs. 1–3) (Plates 1 and 2) Manuscript Received 13.10.59

SUMMARY

A new scincid species (*Egernia saxatilis*) from the Warrumbungle Mountains, New South Wales, and a new subspecies (*Egernia saxatilis intermedia*) from Kanangra Walls, New South Wales, are described. Morphological variations in these forms, and in the closely allied *Egernia striolata* (Peters), are tabulated.

Egernia saxatilis saxatilis appears to be confined to the Warrumbungle Mountains, while *Egernia saxatilis intermedia* is distributed throughout various parts of the eastern highlands. *Egernia striolata* is found largely west of the Great Dividing Range. Although the latter occurs in many parts of Australia, the present study is restricted to specimens from south-eastern Australia.

A microdistributional study within the Warrumbungle Mountains of *Egernia saxatilis saxatilis* and *Egernia striolata* has shown that the former is strictly saxatile in its habits, whereas the latter is equally strict in its preference for an arboreal habitat. It is suggested that these habitat preferences may have been important in maintaining isolation between these two forms in the final stages of speciation. Such morphological features as colour, size and scale rugosity are discussed in relation to the possible advantages which they confer on these two species within their selected habitats.

The available evidence suggests that where *Egernia saxatilis intermedia* and *Egernia striolata* come into contact hybrid zones may occur.

INTRODUCTION

Between 1953 and 1958 a number of specimens of *Egernia* were collected during routine field investigations in the Warrumbungle Mountains. The initial problem arising out of the collection of these animals was their identification, but closer examination disclosed an example of ecological replacement and some interesting correlations were noted.

The preserved material in the collection of the Australian Museum was later studied in the hope that some light might be shed on the problems arising out of the Warrumbungle Mountains investigation. The present study is confined to specimens from eastern Australia, as it is only from this area that adequate collections are available which permit a relatively comprehensive zoogeographical survey.

As a result of the evidence presented in the second part of this paper, formal descriptions of a new species and a subspecies become necessary, and these precede the discussion. They are placed at the beginning to permit the use of the new names in the text, and they are secondary to, and essentially dependent upon, the discussion which follows them.

The bracketed figures following many of the localities mentioned refer in all cases to the relative position of the localities in Plate I, 1.

Egernia saxatilis saxatilis sp. et subsp. nov.

Type.—R15282 in the collection of the Australian Museum; an adult male from the Warrumbungle Mountains, New South Wales. Collected by the author in December, 1958.

Diagnosis.—36-41 mid-body scale rows; four spinose auricular lobules on each side, dorsal colour dark brown, without lighter, broad dorsolateral stripes. For a differential diagnosis, reference should be made to pertinent sections of the general discussion, which are summarised in Table I.

Description of Type.—Head slightly distinct from neck; frontal and interparietal equal in length; width of the former two-thirds its length; interparietal twice as long as broad; two frontoparietals; prefrontals in contact; frontonasal in contact with the rostral; four supraoculars, the first two in contact with the frontal; six supraciliaries; lower eyelid scaly; a post-narial groove on both sides, almost dividing the nasal on the right side only; four spinose auricular lobules on each side; eight supralabials, the sixth and seventh subocular; eight infralabials. Three pairs of pluricarinate nuchals; dorsal scales on body and limbs bicarinate, tricarinate and quadricarinate, with occasional quinquecarinate scales (particularly on the nuchal region); carinations relatively strong (sufficient to make the skin rough to touch); ventral scales smooth, subequal in size to the laterals, which are smaller than the dorsals; 39 rows of scales around the middle of the body; 24 lamellae under the fourth toe; dorsal caudal scales pluricarinate; five pairs of mid-dorsal scales on basal portion of tail, remainder of tail with a single row of mid-dorsal scales; mid-ventral subcaudal scale row enlarged; basal portion of tail slightly compressed dorsoventrally, remainder more or less cylindrical.

Dorsal colour dark brown (almost black in life); many scales with a black bar longitudinally through their centres, these scales being irregularly placed over the dorsal surface; sparsely scattered small, white flecks anteriorly; each alternate scale in the dorsal caudal series with a black posterior edge. Lateral surfaces of body black, with scattered lighter brown scales. Auricular lobules and labials light brown or cream, variegated with darker brown. Gular region white, variegated with black. Ventral surface of body and tail white or cream (bright orange in life). Lower surfaces of feet and digits a shiny black.

Dimensions.—

Total length, 260 mm.;
Head + body, 113 mm.;
Tail, 147 mm.;
Head width (maximum), 21 mm.;
Snout-axilla, 46 mm.;
Axilla-groin, 54 mm.;
Length of right fore limb, 36 mm.;
Length of right hind limb, 49 mm.

Variation.—Variation in the principal diagnostic characters is dealt with in the following pages.

Egernia saxatilis intermedia subsp. nov.

Type.—R15273 in the collection of the Australian Museum; an adult female from Kanangra Walls (3,400 ft.), New South Wales. Collected by the author on April 12, 1959.

Diagnosis.—As for *Egernia saxatilis saxatilis*, except that the auricular lobules, though rugose, are rarely spinose, and may number as few as two on each side; 28-35 mid-body scale rows.

Description of Type.—Scalation and colour as in the type of *Egernia saxatilis saxatilis*, except that the auricular lobules, though very rugose, are not spinose; four pairs of pluricarinate nuchals; 32 rows of scales around the middle of the body; 21 lamellae under the fourth toe; seven pairs of mid-dorsal scales on basal portion of tail.

Most dorsal scales with a central, longitudinal black bar, giving an appearance of narrow, black longitudinal stripes.

Dimensions.—

Total length, 215 mm. +;
Head + body, 113 mm.;
Tail, 102 mm. +;
Head width (maximum), 18 mm.;
Snout-axilla, 45 mm.;
Axilla-groin, 56 mm.;
Length of right fore limb, 31 mm;
Length of right hind limb, 43 mm.

Variation.—Variation in the principal diagnostic characters is dealt with in the following pages.

Juvenile colouration.—Two juvenile specimens (R15270 and R15271) were collected from Kanangra Walls. In these specimens the dorsal and lateral ground colour is black; white scales or scales with white posterior borders are scattered over the dorsal and lateral surfaces. The black head is variegated with white. (Plate II, 3).

DEVELOPMENT OF THE PROBLEM

The Warrumbungle Mountains rise to a height of nearly 2,000 ft. above the surrounding country (4,200 ft. above sea-level), and are remnants of volcanoes which ceased activity during the Tertiary Period. Most of the country is covered by a dry sclerophyll forest (30-70 ft.), with a small tree layer sometimes present. However, in local patches that have been cleared for grazing, local scrub communities of ti-tree (*Leptospermum*) have formed; river she-oaks (*Casuarina*) fringe the watercourses.

There are a number of unusual and impressive rock features which are almost devoid of plant life. These take the form of spires and pinnacles, and are remnants of volcanic plugs from which the cones have been weathered away and which are usually capped by the remains of harder lava flows. (For a summary of the physiography, geology and botany, see Beadle et al., 1948).

Egernia striolata is a very common skink west of the Dividing Range in New South Wales, including the Warrumbungle Mountains. Some 50 specimens were collected in the latter area and many more were seen, and all were found under the loose bark of standing or fallen trees; at no time were any collected from cover on the ground. Whether this species ranges into those areas in the mountains in which snow falls in winter is unknown, although representatives were found from the valley floors to the tops of several of the mountains studied.

The first opportunity to examine the large rocky peaks came in April, 1955, when the author climbed almost to the top of Tonduron Spire (Plate I, 3), a distinctively shaped structure, the lower parts of which are clothed in relatively dense forest, while the upper 300–700 ft. consist of exposed, and often precipitous, rock faces on which only occasional pockets of sparse vegetation exist. Immediately noticeable was the presence of a large, dark *Egernia*, remarkably dissimilar to the arboreal population of *Egernia striolata* found at times only 30 yards below the tree-line. This population was living among large slabs of rock on the cliff faces, and, although a number were seen, owing to the precarious situation only three were collected.

On subsequent trips to the area in 1957 and 1958 five more specimens of this unusual form were taken from a rocky habitat on the Breadknife (A22, B5) and from a rock slide on Mount Dagda (A17, B10; Plate II, 8 and 9), the latter being fully forested as far as the summit. Again, many specimens were observed, but proved difficult to collect. These aberrant specimens may be distinguished from the typical arboreal *E. striolata* by the characteristics listed in Table 1. This form is described as a new species *Egernia saxatilis*.

Table I

Egernia striolata General Series	*Egernia striolata* Warrumbungle Series	*Egernia saxatilis saxatilis* Warrumbungle Series	*Egernia saxatilis intermedia*
Low mid-body scale count (mean 31).	Low mid-body scale count (mean 31).	High mid-body scale count (mean 39).	Low mid-body scale count (mean 32).
Smaller size (mean 97 mm.).	Smaller size (mean 92 mm.).	Greater size (mean 113 mm.).	Greater size (mean 122 mm.).
Light dorsal colouration.	Light dorsal colouration.	Dark dorsal colouration.	Dark dorsal colouration.
Almost smooth dorsal scalation.	Almost smooth dorsal scalation.	Very rugose dorsal scalation.	Very rugose dorsal scalation.
Ventral surfaces of feet light.	Ventral surfaces of feet light.	Ventral surfaces of feet black.	Ventral surfaces of feet black.
Ventral surface pale orange in life.	Ventral surface pale orange in life.	Ventral surface bright orange in life.	Ventral surface bright orange in life.
Supralabials white.	Supralabials white.	Supralabials variegated with darker.	Supralabials variegated with darker.
Auricular lobules small, scale-like.	Auricular lobules small, scale-like.	Auricular lobules long,u sually spinose.	Auricular lobules, though rugose, rarely spinose.
17-23 lamellae under 4th toe (mean 19).	18-22 lamellae under 4th toe (mean 19).	20-24 lamellae under 4th toe (mean 22).	19-25 lamellae under 4th toe (mean 22).

The real interest of the case outlined above lies in four directions :—

(1) The apparent close link between general morphology and the habitat occupied.

(2) The potential advantages of the principal morphological features of *E. saxatilis* within its selected habitat.

(3) The genetic status of the forms within the *striolata-saxatilis* complex and the circumstances under which they developed.

(4) The systematic treatment of the problem.

It is evident that these four problems are interdependent, but for clarity they are discussed separately in the following pages.

MORPHOLOGICAL VARIATION, DISTRIBUTION AND HABITAT PREFERENCES

For the purposes of the present discussion, the available specimens have been separated into four series :—

(1) Typical *Egernia striolata* from the Warrumbungle Mountains.

(2) *Egernia saxatilis saxatilis* from the Warrumbungle Mountains.

(3) Typical *Egernia striolata* from other localities in eastern Australia.

(4) Forms intermediate in characteristics between *E. striolata* and *E. s. saxatilis* (*Egernia saxatilis intermedia*) from other localities in eastern Australia.

Series (1) and (3) are morphologically and ecologically indistinguishable, and have been treated separately only to allow comparisons to be drawn between the two sympatric Warrumbungle Mountains populations. Hence, the material can be divided into three distinct morphological groups—*E. striolata*, *E. s. saxatilis* and intermediates between the two.

Significant variation has been noted in the following external morphological features :—

(1) The number of mid-body scale rows.

(2) Maximum size.

(3) Body colour (dorsal and ventral).

(4) Rugosity of the scale carinations.

(5) Colour on ventral surfaces of feet.

(6) Colour of labial scales.

(7) Number of lamellae beneath the fourth toe.

(8) Number and rugosity of the auricular lobules.

Of these characters, the first four have been used as major diagnostic features because of their constancy within a population and the degree of variation between the different series studied. The remainder, though less constant, can be used to indicate definite trends, and have been used to substantiate the conclusions drawn from the above four morphological features, together with ecological and geographic evidence.

Table I is a summary of the essential morphological differences between the four series of specimens listed above, and Figures 1 and 2 illustrate graphically and quantitatively some of these differences. The distribution of these various forms is shown in Figure 3. Together with the morphological differences outlined above, the differences in habitat preference within the Warrumbungle Mountains (as mentioned earlier) should be stressed, as it is considered that they may have played an important part in the process of speciation. No exception to the arboreal habitat of *E. striolata* was observed, and similarly all of the *E. s. saxatilis* collected and observed were restricted to a rocky habitat. It can be seen from Plate I, 1, that the only areas in the Warrumbungle Mountains in which the rock-dwelling form has been found are very restricted and that they are surrounded by an environment inhabited only by *E. striolata.*

A knowledge of the habitat of *E. s. saxatilis*, together with an aerial photograph of the area (Plate I, 1), would probably allow one to plot accurately the distribution of this form within the Warrumbungle Mountains. The evidence suggests that this species is to be found only on the isolated, open, exposed rock masses and slides, which can be seen distinctly in the photograph.

The occurrence of numerous rock slides in the area (e.g., A21, B14; A15, B10; A18, B3) would probably permit an interchange of individuals between the otherwise isolated populations of *E. s. saxatilis.* Furthermore, if this form occurs outside the area under discussion (it is possible that it can be found in other isolated mountains, such as the Nandewar Range) then it is evidently effectively isolated from its Warrumbungle Mountains representatives.

The demonstration of this correlation between habitat and morphology led to a programme of widespread collection of members of this species complex in New South Wales. A large number of typical *E. striolata* have been collected by the author in many parts of New South Wales during the past 10 years, and nearly all were found under arboreal conditions. Of the intermediate forms listed above, the author has collected specimens at Kanangra Walls and on the highlands behind Wollongong, New South Wales; nearly all were found in a rocky habitat. However some specimens collected from the latter locality were found in hollow logs and in tree stumps, so it is apparent that the saxatile habits of this form are not as strict as in its Warrumbungle Mountains relatives.

It will also be noted that there is apparently no close correlation between the distribution of either the intermediate series or typical *striolata* and any major topographical feature or environmental component. There is merely a tendency for the former to occupy an area roughly restricted to the eastern highlands and the latter to occupy a lowland habitat, although each extends into the other's territory when the latter appears to be absent. This interdigitation has been shown in Figure 3, in which an arbitrary altitude of approximately 500 metres has been chosen to represent the highland regions.

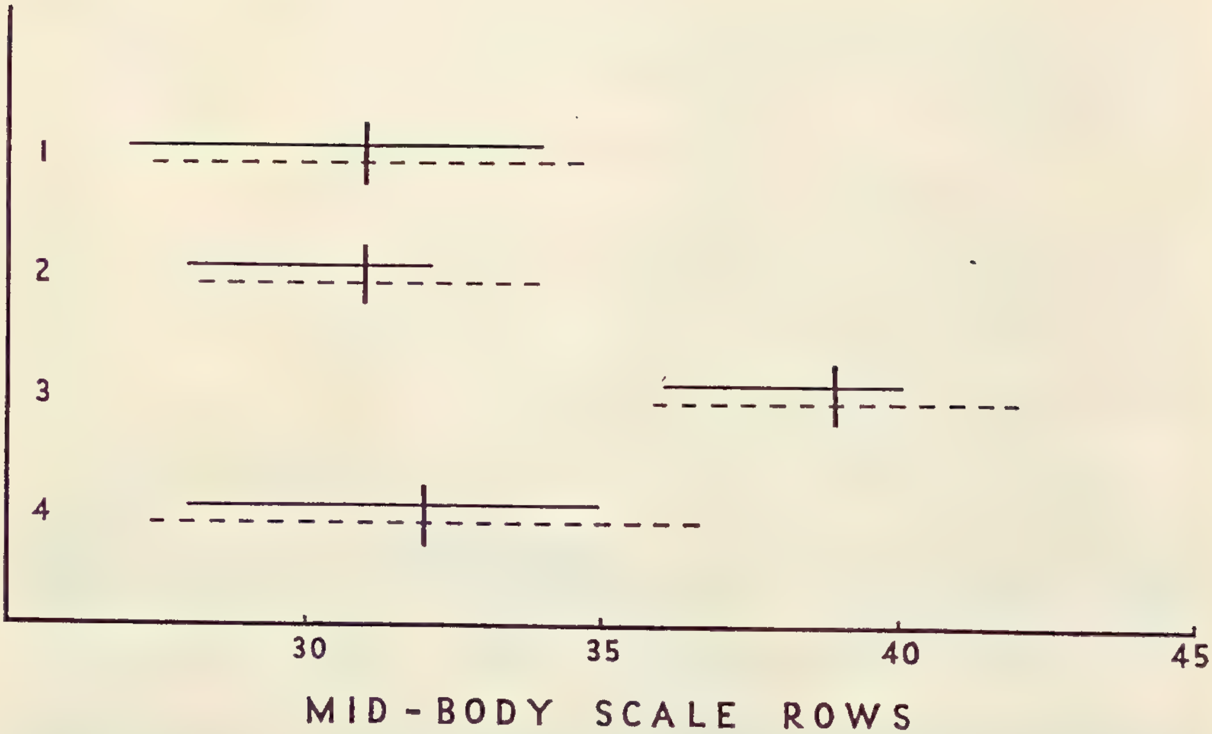


Figure 1.—Graph showing differences in relative scale size (as indicated by the number of mid-body scale rows) in *Egernia striolata*, general series (1); *Egernia striolata*, Warrumbungle Mountains series (2); *Egernia saxatilis saxatilis* (3), and *Egernia saxatilis intermedia* (4). The vertical bar represents the mean value, the solid horizontal bar the observed variation, and the broken horizontal bar four standard deviations.

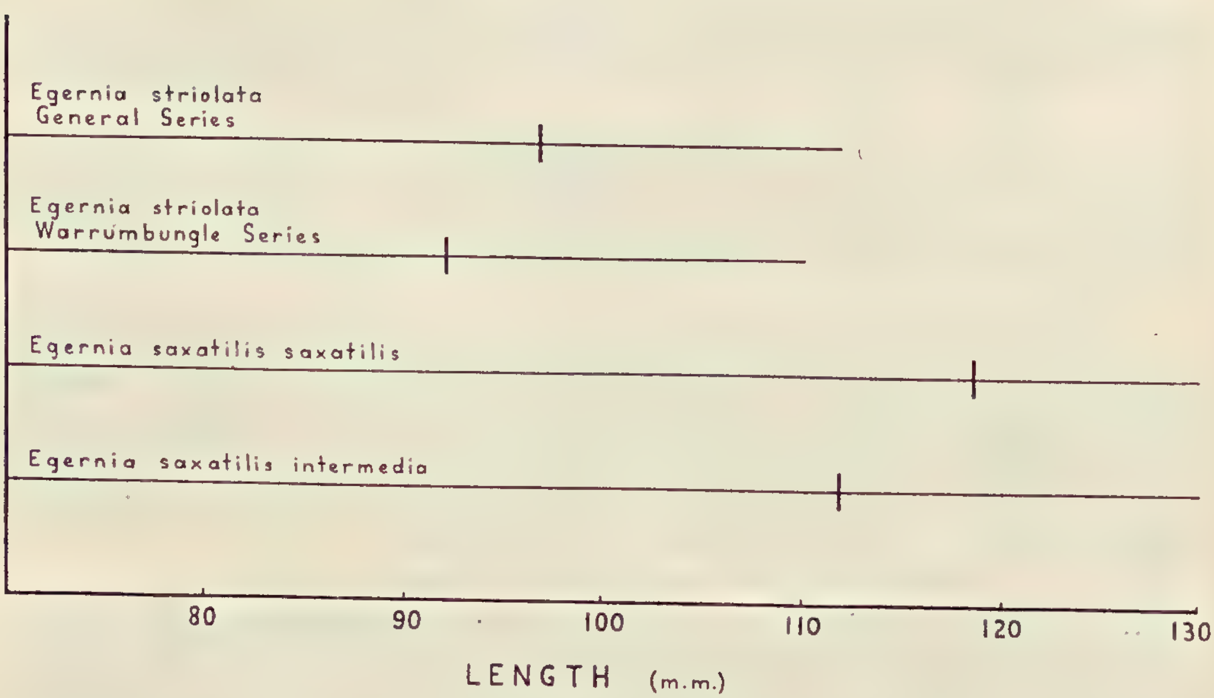


Figure 2.—Graph showing the mean size (vertical bar) and the total observed variation of the four series listed above. The means were determined using all specimens more than 70 mm. in length (snout-vent), this figure being chosen to represent an arbitrary minimum size for adulthood.

Figure 3.—Map showing locality records in south-eastern Australia of specimens examined of *Egernia striolata*, *Egernia saxatilis saxatilis* and *Egernia saxatilis intermedia*. The shaded area represents all altitudes over 1,600 ft. (500 metres).

SELECTION AND MORPHOLOGICAL CHARACTERISTICS IN EGERNIA SAXATILIS

Intensive selection would appear to be responsible for the morphological features associated with the more specialised habitat preferences of *E. saxatilis* within the Warrumbungle Mountains. For this reason, it is important to attempt to determine the potential advantages of those features of *E. saxatilis* which distinguish it from *E. striolata* :—

(1) *Melanism* :—Parker (1935) discussed the advantages of melanism to poikilothermic animals living on barren rock surfaces in tropical and temperate areas, and this would probably account for melanistic tendencies in *E. saxatilis.* The author agrees with Parker that the protective nature of such colouration is probably secondary to its thermoregulatory function.

(2) *Larger size* :—The advantages of the larger size of *E. saxatilis* are not obvious, for the relative decrease in surface area with larger size would mean that heat loss by radiation would be less than in the smaller *striolata.* However, as the saxatile environment (associated partly with altitude) is usually subject to greater temperature extremes than the forested areas, this increase in body size may be associated with heat conservation at low temperatures.

It would appear, then, that melanism and increased size interact to provide optimal thermoregulatory control within such a distinctive environment.

(3) *Rugose scalation and smaller dorsal scales* :—In an attempt to determine quantitatively the potential advantages of the rugose scalation and the smaller mean scale size in *E. s. saxatilis*, specimens of this form and of *E. striolata* from the Warrumbungle Mountains series were examined. As the ventral scales are more or less equal in both forms, it is evident that the mean size of the dorsal and lateral scales (which bear the carinations) in *E. s. saxatilis* is smaller than in *E. striolata.* Hence, as there are. on the average, between four and seven extra longitudinal rows of scales over most of the body in *E. s. saxatilis*, and as this form has approximately 65 transverse rows of scales (between the nape and the base of the tail) as compared with approximately 55 rows in *E. striolata*, it can be seen that the former possesses somewhere between 300 and 600 scales more than the latter. Apart from the fact that the rugosity of the scalation is much greater in *E. s. saxatilis*, if one considers that the average number of carinations on each extra scale would be approximately three, then it is evident that *E. s. saxatilis* possesses between 900 and 1,800 more carinations than *E. striolata.* The increase in rugosity, size and number of the auricular lobules, together with a greater number of infradigital lamellae, would also assist in maintaining a purchase in the rocky environment. The wedging effect of these characteristics may also be important in reducing predation, for when any attempt is made to extricate these lizards from the rocky crevices in which they live the body is inflated so as to press the rugose scales against irregularities in the rock surface, the auricular lobules are raised for the same purpose and the tail is turned toward the aggressor to enable the backwardly-directed rugosities to gain full purchase.

THE GENETIC STATUS OF FORMS WITHIN THE STRIOLATA-SAXATILIS COMPLEX AND THE CIRCUMSTANCES UNDER WHICH THEY DEVELOPED

Egernia striolata has an Australia-wide distribution, being absent only from various relatively restricted areas where unsuitable environmental conditions prevail. The limits of the variation which have been described for this widely-ranging species (Mitchell, 1950) do not overlap with those described in the present paper for *Egernia s. saxatilis.* It is therefore evident that morphological differences of this nature are of such magnitude that they could arise only as a result of effective isolation over a long period. The fact that these two forms coexist (geographically) in the Warrumbungle Mountains with complete genetic stability is supporting evidence of the specific recognition afforded them in the present paper.

It is known that where two closely related sympatric species occupy different habitats, the local absence of one may result in the occupation of both habitats by the other within that area. In eastern Australia, *E. s. intermedia*, though primarily saxatile, is sometimes found under arboreal conditions where these are available and where *E. striolata* is absent. Conversely, the latter is sometimes taken in the rocky habitat in areas where *E. s. intermedia* does not occur. Mr. F. J. Mitchell informs the author that the South Australian *E. striolata* (not covered in the present paper) are essentially saxatile, although morphologically indistinguishable from their arboreal eastern representatives. This lack of strict habitat segregation outside areas of overlap need in no way reduce the significance of the Warrumbungle Mountains complex.

It is evident that strictness of habitat preference can only be of significance in the speciation process when two closely allied allopatric forms come together, for only then can such factors as competition and degree of genetic stability determine the fate of the two forms.

Suppose that, as a result of the setting-up of a geographic barrier (and after a sufficient period of time), a species is divided into two distinct races, each potentially capable of interbreeding with the other. Should this barrier be broken down, either extensively or at one point, and the two races allowed to meet, there are but two possible consequences. Either the two races will freely interbreed, resulting in a hybrid zone (or a complete loss of separate identity) or, due to some ecological or behavioural differences between the two races, psychological barriers (in the broadest sense) will be set up which prohibit interbreeding just as effectively as do genetic or physical (morphological) ones. In this case, as a result of selection pressure and various competitive factors, differences in ecology and behaviour will tend to become exaggerated and hence assist in the maintenance of reproductive isolation. In this manner it would be possible for the *completion* of the speciation process to take place under conditions of sympatry.

Mayr (1942) considers that differences in habitat preference cannot result in sympatric speciation. Hinde (1959) states that ". . . differences in habitat preference between sympatric or incipient species may be important in reducing both interbreeding and competition". He also concludes that such differences ". . . are sometimes conducive to reproductive isolation". He rather questionably supports this (in part) by pointing out that sympatric closely-related bird species frequently occupy different habitats.

It would certainly appear that habitat preferences, no matter how significant in the later stages, *can not initiate species formation*, and therefore it is highly improbable that ecological differences between *E. striolata* and *E. saxatilis* could originate other than by geographic isolation.

It is possible that the case under discussion represents an example of *character displacement* (Brown and Wilson, 1956), in which two allopatric species meet, their differences becoming exaggerated in the zone of overlap due to genetic reinforcement and/or ecological displacement. However, the author considers that if two distinct (reproductively incompatible) species were involved, one would expect character displacement to occur in other zones or overlap, but this does not seem to be the case. Although the evidence is admittedly inconclusive, it would appear that hybrid zones do exist wherever *E. striolata* and *E. saxatilis intermedia* come together, for specimens apparently lying between these two forms have been taken at Cootamundra, New South Wales, and from the northern coastal regions of New South Wales (page 104).

Taking into account the various factors brought out in the preceding discussion, to what extent can the origins and phyletic relations of the three forms under discussion be determined ? It is suggested that the differentiation of the three forms was probably initiated as a result of some geographical isolating mechanism. In this way a formerly widely-ranging species was broken up into two diverging populations, one of which (on present data) tended to be restricted to the well-forested highlands of eastern Australia and the other to the grassy open sclerophyll of the drier inland regions. (*E. striolata* has reached coastal districts in a number of places, however, apparently through breaks in the mountain barrier—for example, via the Hunter River valley). Possibly as a result of the environmental conditions found in the areas in which they occurred, each form tended toward a particular habitat, the highland form (*E. s. intermedia*) inhabiting rocky areas, the lowland form (*E. striolata*) choosing an arboreal existence.

The Warrumbungle Mountains, by virtue of their structure, probably represented a western outpost and refuge for *E. s. intermedia*, which was cut off from the parental eastern stock. This separation was probably due to a secondary invasion of *E. striolata* from the west, and physiographical changes in the intervening country may have been involved. In any case, with the eventual breakdown of the initiating geographic barrier the two races came together, at least within the Warrumbungle Mountains, and possibly in other parts of their ranges.

The result appears to have been that within the Warrumbungle Mountains initial habitat preferences became exaggerated and hence prohibited reproductive exchanges between the two races. Finally, through lack of interbreeding, the two forms achieved full genetic stability associated with constant differences in morphology and characteristic habitats. Hence, the Warrumbungle Mountains complex is apparently a case of partial sympatric speciation, in which at least the final stages of species formation (from subspecific to specific status) evolved under conditions of sympatry.

However, the evidence (though incomplete) suggests that there may occur in other parts of the range the other of the two possible consequences of two overlapping races, the formation of a hybrid zone in which all morphological and ecological intermediates may be found.

SYSTEMATICS

As has already been noted, the coexistence of *E. striolata* and *E. s. saxatilis* within the Warrumbungle Mountains with complete genetic stability, together with the constancy and degree of their morphological differences, would indicate that the most reasonable solution would be to afford them full specific status.

The taxonomic relationships of the intermediate specimens are not so apparent, however. As can be seen from Table I, they can be readily distinguished from either extreme. Nevertheless, the only characteristic of *E. s. saxatilis* which they lack is the higher scale-row count, so that it would appear that their affinities lie closer to *saxatilis* than to *striolata*.

However, although these specimens are morphologically distinct from *E. striolata*, the two appear to occupy different geographical regions; hence, it has not been possible to determine whether they represent genetically stable, specifically distinct forms.

Within the series of intermediate forms, however, are three specimens (R793, R11859, R12740) which appear to be much closer to *E. striolata* than the others, and this would indicate that there is a gradation from one form to the other, particularly in the northern part of New South Wales. Whether any true zones of sympatry or hybridisation occur is difficult to determine. The only potential example in the present study was the record of several typical *striolata* from Cootamundra, together with one example possessing a number of intermediate characteristics.

It would therefore appear that the series of specimens which have been labelled "intermediates" are probably intermediates in the strictest sense—that is to say, they represent, morphologically and ecologically, an intermediate stage in the differentation of *E. saxatilis* from *E. striolata*. They are probably genetically labile (as a group, but undoubtedly with exceptions), and not isolated reproductively from either *striolata* or *saxatilis*. How, then, are these intermediate specimens to be placed in the present scheme of classification ? Perhaps the most satisfactory solution would be to relegate them to subspecific status, as they are apparently morphologically distinguishable geographic representatives of either *E. saxatilis* or *E. striolata*, depending on which of these can be considered as the parental stock. However, the same problem arises as in a circular cline, for although the two sympatric extremes are reproductively isolated, allocation of any intermediate population to either extreme infers a false reproductive isolation between it and the other extreme. On the other hand, if the intermediate form is not named distinctively it must be relegated to either one species or the other, thus providing an even falser picture.

Although the obvious solution would be to avoid taxonomic categories altogether, and merely present the evidence as an interesting example of the interaction of morphology and habitat, the author considers that the application of a name to the intermediate series would serve a greater function than mere museum "pigeon-holing". For this reason, this series is described as a race (*intermedia*) of *Egernia saxatilis*, though the decision to place *intermedia* as a race of *saxatilis* rather than of *striolata* is an arbitrary one and tends to conceal true phylogenetic relationships. Nevertheless, it should be stressed that this decision has been made because of the apparent close affinities (in morphology and ecology) between *intermedia* and *saxatilis*, and does not necessarily indicate reproductive incompatability between the former and *striolata*.


A 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
B 1 2 3 4 5 6 7 8 9 10
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Explanation of Plates

Plate I

1. Aerial photograph of that section of the Warrumbungle Mountains, New South Wales, in which most of the present study was carried out. The two grid scales have been added to allow ready reference to the various places mentioned in the text.

2. Crater Bluff (A22, B9), viewed from Mount Dagda.

3. Tonduron Spire (A17, B33), viewed from below the Picnic Ground (A4, B25).

Plate II

1. Dorsal view of holotype of *Egernia saxatilis saxatilis.*

2. Dorsal view of holotype of *Egernia saxatilis intermedia.*

3. Dorsal view of juvenile *Egernia saxatilis intermedia* from Kanangra Walls, New South Wales.

4. Lateral view of head of *Egernia striolata* from the Warrumbungle Mountains.

5. Lateral view of head of holotype of *Egernia saxatilis intermedia.*

6. Lateral view of head of holotype of *Egernia saxatilis saxatilis.*

7. Plateau at Kanangra Walls, type locality of *Egernia saxatilis intermedia.*

8. Small cliff above rock slide (A17, B10) on Mount Dagda, typical of similar areas throughout the Warrumbungle Mountains in which *Egernia saxatilis saxatilis* occurs.

9. The rock slide below the cliff shown in (8).

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SOME AUSTRALIAN TINGIDAE (HEMIPTERA), INCLUDING NEW GENERA AND NEW SPECIES

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(Plates III—VI) Manuscript received 10.3.60

Through the kindness of Dr. J. W. Evans, Director of the Australian Museum, Sydney, I have received an interesting collection of Australian Tingidae for determination. This collection contains a number of rare species, including two new genera and five undescribed species. The holotypes and allotypes are in the Australian Museum; paratypes are also there and in the Drake Collection (U.S. National Museum). The illustrations in this Record are by Patricia J. Hogue, of Arlington, Virginia, and were made possible by U.S. National Science Foundation Grant No. 4095.

Dictyla amitina (Horvath)—(Plate III)

Monanthia amitina Horvath, 1923 : 13

Mt. Pipps, Queensland, Australia, three specimens, 9.i.1931, common species. In a paper in press elsewhere, the Genus *Monanthia* Le Peletier et Serville has been suppressed as a synonym of the Genus *Copium* Thunberg, and the Genus *Dictyla* Stål resurrected from synonymy to receive most of the species previously included in *Monanthia*.

Dictyla aima, new species—(Plate III)

Head very short, deep black, armed with five rather slender, appressed, testaceous spines, the hind pair longer than the others; eyes large, transverse, black; bucculae blackish fuscous with the inferior margin testaceous, areolate, contiguous in front. Antennae indistinctly pubescent, pale testaceous, with last segment largely blackish and pubescent, measurement: I, 7; II, 5; III, 52; IV, 16. Labium brown with apex blackish, reaching to middle of mesosternum; laminae rather low, uniseriate, black, more widely separated and cordate on metasternum, closed behind. Orifice of metathoracic scent glands indistinct. Hypocostal laminae uniseriate. Body beneath black. Length 2·25 mm.; width 0·92 mm.

Pronotum black-fuscous with veinlets of collar, paranota, carinae and hind triangular process largely testaceous, some veinlets infuscate; collar truncate in front, transversely biseriate; median carina distinctly elevated, composed of one row of moderately large, rectangular areolae; lateral carinae short, visible behind paranota, divergent posteriorly, with their apices elevated so as to form larger areolae; posterior process areolate. Paranota large, reflexed, with outer margins resting on pronotal surface but not extending inwards to median carina, with discal part of each slightly elevated above pronotal surface. Elytra a little wider and longer than abdomen, with areolae clear; costal area rather wide, composed of one row of fairly large, quadrate or rectangular areolae; subcostal area scarcely wider in widest part than costal area, biseriate; discoidal area nearly extending to middle of elytra, with outer boundary vein subangulately elevated just before apex, widely angulate at apex, widest at apex of outer boundary angle, there three or four areolae deep; discoidal area composed of rather large areolae. Wings nearly as long as elytra, brownish.

Holotype (male) and *allotype* (female), Queensland, on " cuolahah box ", 20. ix. 1933, A. Musgrave. *Paratypes*: four specimens, same labels as type.

This new species resembles *D. amitina* (Horvath, 1925), also from Queensland, but may be readily distinguished by the distinctly higher median and lateral carinae, by the discal part of the reflexed paranota being slightly elevated above the pronotal surface, and also by the wider costal areas of elytra. Both species are very similar in size, form and color. In *amitina* the paranota are completely reflexed, and rest flatly on the pronotal surface with outer margins touching (or nearly so) the median carina.

Physatocheila civatis Drake

Physatocheila civatis Drake 1942 : 10

North Rocks, one specimen, 10. i. 1941, W. Driscoll; two specimens, Fuller's Bridge, New South Wales, Australia. Also known from Queensland.

Physatocheila objicis Drake

Physatocheila objicis Drake 1942 : 10.

Bogan River, New South Wales, four specimens, x. 1932. Known only from New South Wales and Queensland.

Froggattia olivinia Froggatt

Froggattia olivinia Froggatt 1901 : 1592-1601, pl. 12, fig. 14.

Froggattia olivina Horvath 1902 : 604-605.

Froggattia olivina Hacker 1927 : 25.

Drummoyne, New South Wales, 29. xii. 1911, two specimens. Specimens from Queensland and Tasmania, Australia, have also been studied. This lace-bug is a pest of the olive tree and feeds on the undersides of the leaves. Froggatt (1901 : 1601) gives a good account of its habits and feeding activity.

This genus and species have been wrongly accredited to Horvath (1902) as *Froggattia olivina* in collections and literature since they were originally described. However, Froggatt's descriptive notes, colored figure of adult and economic account of the olive tingid as *Froggattia olivinia* (wrongly attributed by Froggatt himself to Horvath) have priority by almost one year over that of Horvath. Under these circumstances, *Froggattia olivinia* has precedence and thus is the valid technical name for the olive tingid.

Oncophysa vesiculata (Stål)

Monanthia (Physatocheila) vesiculata Stål 1859 : 259.

Oncophysa vesiculata Stål 1873 : 129.

Oncophysa vesiculata Horvath 1925 : 2.

Oncophysa vesiculata Hacker 1928 : 177, fig.

Buna Mts., Queensland, 2,000 ft., 22. i. 1928, one specimen, N. Geary. Specimens from New South Wales are also at hand.

Var. *nigra* Hacker, 1928 : 178, fig., National Park, New South Wales, four specimens, 21. v. 1924, A. Musgrave; Davis Gap, Mt. Kosciusko, New South Wales, 10, i. 1929, A. Musgrave; Mt. Tomah, New South Wales, two specimens, 9. ii. 1929, all collected by A. Musgrave and from New South Wales. Also recorded from Victoria and Tasmania, Australia.

Var. *gracilis* Hacker 1928 : 178. Sawpit Creek, Mt. Kosciusko, New South Wales, 3. i. 1929, A. Musgrave. Also known from South Australia.

Diplocysta trilobata Drake and Poor

Diplocysta trilobata Drake and Poor 1939 : 205.

Cooper Park, Bellevue Hill, Dr. K. K. Spense, four specimens. This species differs from *D. bilobata* Horvath, from Western Australia, in the shape and form of the large pronotal cysts. The upper two cysts in *trilobata* are distinctly separated from each other. The types of the latter came from Victoria, and I also have specimens from Tasmania and South Australia.

Codotingis evansi, new sp. (Plate IV)

Rather small, oblong, chestnut-brown, with some veinlets of elytra infuscate, head blackish fuscous, paranota and carinae of pronotum largely testaceous, appendages brown with apical half of last tarsal segment and also of terminal segment of antennae blackish. Body beneath dark brown. Length 2·90 mm.; width 1·00 mm.

Head very short, wide, armed with five brown or testaceous spines; median spine tuberculate, placed at centre of vertex; anterior spines situated slightly behind front margins of eyes (one on each side of median line); hind pair of spines appressed, widely separated, situated considerably behind inner margins of eyes, extending anterior nearly to middle of eyes. Antennae rather short, finely granulate, clothed with fine, inconspicuous, yellowish pubescence, measurements: I, 10; II, 8; III, 68; IV, 24. Labium rather stout, dark brown, extending almost to middle of metasternum; laminae low, testaceous, parallel, open behind. Metapleural scent gland orifice indistinct. Hypocostal laminae uniseriate. Legs rather short, indistinctly pubescent, the femora only slightly swollen.

Pronotum moderately transversely convex across humeri, punctate, tricarinate, all carinae distinct, rather thick, without areolae; median carina connected in front with hood; lateral carinae slowly diverging anteriorly, terminating anteriorly opposite apex of median carina but not in contact with hood; paranota long, rather narrow, uniformly dilated, uniseriate, reflexed upward, with dorsal side in contact with pronotum at humeral angles. Hood small, inflated,

projecting anteriorly over basal part of head and posteriorly over most of calli, with measurements of length, width and height practically the same; posterior process areolate. Elytra strongly narrowed beyond discoidal area, divided into the usual areas; costal area fairly wide, composed of one complete and a partial second row of areolae on the basal half, the areolae moderately large; subcostal area slightly wider, biseriate, nearly vertical; discoidal area five-ninths as long as elytra, five areolae deep beyond middle just behind apex of posterior pronotal process, the areolae scarcely larger than those of subcostal area; areolae beyond basal third of sutural area considerably clouded with dark fuscous.

Holotype (male), Moruen District, Queensland, April, 1941, N. Geary. *Paratype*: One specimen, taken at same time as type.

Differs from *C. recurva* Drake, only other member of the genus, in having slightly longer antennae, much thicker and more elevated carinae, wider paranota, and wider costal areas of elytra. In both species the hood is similar in form and about the same size. This species is named in honor of Dr. J. W. Evans, Director of the Australian Museum, who has published many papers on Australian insects, especially Homoptera. The type is figured.

Alloeocysta, new gen.

Head very short, scarcely extended in front of eyes, armed with five spines; bucculae short, areolate, with apices meeting in front. Labium moderately long, extending beyond prosternum; laminae areolate, more widely separated on metasternum. Antenniferous tubercles short, blunt, rounded in front. Antennae rather short, rather slender, with segments I and II short, III longest, rather slender, IV moderately swollen and much shorter than III. opening of metapleural scent gland not visible. Hypocostal laminae uniseriate. Pronotum moderately narrowed in front of humeri, tricarinate; median carina long, reaching to hood; lateral carinae present on posterior process, modified so as to form long, subcylindrical, inflated, areolate cysts on pronotum proper; paranota long, moderately wide, reflexed upright; hood moderately large, extending over basal part of head, transverse, wider than long. Elytra a little wider and longer than abdomen, without tumid areas, divided into the usual areas, with discoidal area extending beyond middle of elytra. Wings present, longer than abdomen. Legs moderately long, moderately stout.

Type of genus: **A. approba**, new sp. (Plate V).

Separated from other Australian genera by having the hood distinctly wider than long and the lateral carinae inflated, cystlike on disc of pronotum.

Alloeocysta approba, new sp. (Plate V)

Small, oblong, brownish or brownish testaceous, with veinlets brownish or somewhat fuscous, pronotum black, areolae of hood and cysts of lateral carinae clouded with fuscous, body beneath brownish fuscous with pronotal sterna darker. Antennae testaceous with apical part of last segment infuscate. Legs testaceous with last tarsal segment infuscate. Wings smoky brown. Labium brown with apex infuscate. Areolae of costal area and paranota largely clear. Length 3·00 mm.; width 1·30 mm.

Head armed with five, moderately long, suberect, whitish spines; eyes black. Antennae indistinctly pubescent, measurements: I, 9; II, 7; III, 70; IV, 18. Labium scarcely extending to metasternum; laminae divergent on mesosternum, more widely separated and cordate on metasternum. Pronotum broadly transversely convex across humeral angles; median carina elevated, pale, very distinct; lateral carinae greatly modified so as to form elongate, subcylindrical, divergent (anteriorly) vesicles (Plate V) on pronotum proper, then short, parallel and cariniform on posterior process; paranota long, almost uniformly dilated, erect, mostly three areolae deep, slightly less reflexed opposite humeral angles; posterior process triangular areolate, subrectangular in outline, with apices overlapping in repose; costal area fairly wide, uniseriate (sometimes with one extra cell in widest part), the areolae fairly large, clear and subquadrate, with transverse veinlets dark fuscous; subcostal area moderately wide, largely biseriate, subvertical; discoidal area large, narrowed and acutely angulate at both ends, five-ninths as long as elytra, with boundary veins raised, widest behind middle, there four areolae deep; sutural area with areolae slightly enlarged apically. Wings nearly as long as elytra, fumose. Legs indistinctly pilose, moderately stout. Female unknown.

Holotype (male), Bogan River, New South Wales.

The type is illustrated (Plate V). The shape of hood and paranota separate this singular tingid from other members of the family inhabiting Australia.

Tingis exalla, new sp.

Elongate, nearly parallel-sided, brown, with head and eyes black; antennae brown with apical half of last segment blackish. Body beneath dark brown with mesosternum and metasternum blackish. Legs and antennae provided with very short, inconspicuous, golden pubescence. Length 4·00 mm.; width 1·25 mm.

Head very short, armed with five short, brownish spines, the hind pair appressed and others semiporrect; antenniferous tubercles bluntly rounded, brown. Antennae rather long, rather slender, segment IV moderately swollen apically, measurements: I, 14; II, 11; III, 90; IV, 30. Labium fuscous, nearly reaching to metasternum; laminae testaceous, uniseriate, parallel on mesosternum, more widely separated and cordate on metasternum, open at middle behind. Bucculae short, with ends meeting in front, areolate. Openings of metathoracic scent glands distinct, with sides of channel raised, nearly upright. Legs long, fairly stout but not incrassate.

Pronotum moderately narrowed anteriorly, broadly convex across humeri, closely punctate; tricarinate, all carinae raised but not areolate; median carina terminating anteriorly on collar; lateral carinae ending in front at calli, feebly divergent from base of pronotal disc anteriorly; paranota very narrow, linear, reflexed against sides of pronotum, with one row of tiny areolae; collar rather long, truncate in front, punctate; posterior process long, triangular, areolate. Elytra scarcely wider than pronotum, not much longer than abdomen; costal area very narrow, composed of one row of tiny areolae; subcostal much wider, subvertical, composed of two rows of small areolae; discoidal area large, seven-twelfths as long as elytra, with outer boundary vein slightly arcuate; ten areolae deep at widest part opposite apex of posterior pronotal process, with areolae rather small and about same size as in basal part of suteral area. Wing dark fumose, a little longer than abdomen.

Holotype (male) and *allotype* (female), both mounted on same card, Kosciusko, New South Wales, elevation 5,000 ft., R. Helms. Paratypes: two specimens, same data as type, also both mounted on a rectangular card.

The elongate form, nearly parallel-sided body, very narrow paranota and very narrow costal area of the elytra distinguish this species from its Australian congeners. It belongs to the subgenus *Tingis*.

Tingis hurdae Drake

Tingis hurdae Drake 1947 : 113, fig.

Hornsby, Queensland, one specimen. So far, only known from Queensland.

Tingis drakei Hacker

Tingis drakei Hacker 1929 : 328, fig.

Bunya Mts., Queensland, two specimens. Originally described from Queensland and known only from there.

Paracopium australicum (Stål)

Catoplatus australicus Stål 1873 : 128.

Paracopium australicus Hacker 1927 : 20, fig.

Bunya Mts., Queensland, 22. xii. 1937, 3,000 ft., four specimens, N. Geary. This gall-making tingis is known only from Australia.

Paracopium albofasciata Hacker

Paracopium albofasciata Hacker 1927 : 21, fig.

Clermont, Queensland, vii. 1929, Dr. K. K. Spense. Recorded only from Queensland. The host plants of this species and other gall-forming tingids in Australia are unknown.

Parada popla Drake

Parada popla Drake 1942 : 3.

National Park, Macpherson Ridge, Queensland, xii. 1926, A. Musgrave, one specimen. Original described from Queensland; known only from that region.

Parada torta Drake

Parada torta Drake 1942 : 4, 1952 : 147.

Mt. Tomah, Queensland, four specimens. Known previously from Queensland and New South Wales.

Eualana tasmaniae Drake

Eualana tasmaniae Drake 1945 : 97.

Gordon, New South Wales, 14. xi. 1948, two specimens, on cones of *Banksia robur* var. *minor*, A. Musgrave. The types were taken in Tasmania (Hobart). Two other specimens are before me which bear the label " Fischer Australia, Post 1, 1870 ".

Genus **Chorotingis,** new gen.

Head long, porrect, strongly produced in front of eyes, with apex extending beyond first antennal segment, inserted into head up to hind margins of eyes; eyes moderately large, transverse; bucculae very long, parallel, areolate, with ends slightly surpassing apex of head but not curved inward so as to meet in front of clypeus. Labium very long, extending beyond sulcus; laminae areolate, not very widely separated, parallel, open behind. Antenniferous tubercles short, blunt, rounded in front. Antennae rather short, moderately stout; segments I and II short, the latter a little smaller; III moderately long, not much slenderer than II; IV moderately long, slightly incrassate. Orifice of metasternal scent glands indistinct. Legs rather short, with femora a little swollen but not incrassate. Hypocostal laminae long, uniseriate.

Pronotum moderately broadly convex, punctate, with lateral sides slowly and evenly converging in front of humeri, tricarinate; collar feebly produced in front, areolate, elevated at middle so as to form a very small hood; paranota long, areolate, not produced anteriorly beyond collar nor posteriorly behind humeri, with outer margins jointly rounded and thus without angles, feebly reflexed; posterior process long triangular, acutely angulate at apex, areolate; elytra scarcely wider than greatest width across pronotum and paranota, wider and longer than abdomen, with moderately large areolae, divided into costal, subcostal, discoidal and suteral areas, the discoidal area extending beyond middle of elytra. Wings longer than abdomen.

Type species, **Chorotingis indigena,** new sp. (Plate VI).

This genus belongs to the subfamily Tinginae and may be distinguished at once from other genera of this subfamily occurring in Australia by having a long head (strongly produced in front of the eyes) and by the long bucculae. The large triangular posterior process of pronotum and lack of visible clavus separate it at once from Cantacaderinae, though the long head and long bucculae remind one somewhat of this subfamily.

Chorotingis indigena, new sp. (Plate VI)

Large, obovate, without vestiture, areolae rather small and clear, brown paranota and costal area brownish testaceous, the head fuscous-brown; body beneath darker brown with mesosternum and metasternum blackish; Length 4·00 mm.; width 1·80 mm. (across widest part of elytra).

Head broad, nearly flat above, width across eyes and median length subequal (47 : 48), width of vertex and length of clypeus in front of anterior pair of spines also subequal (26 : 26); median and anterior pair of spines rather short, erect, blunt, the posterior pair bent anteriorly; bucculae long, wide areolate, with anterior ends slightly surpassing but not meeting in front of clypeus; antenniferous tubercles short, blunt, concave within, with apices rounded. Labium reaching almost to apex of second abdominal tergite; laminae pale, rather low, uniseriate. Antennae rather short, with short, inconspicuous, golden pubescent hairs on first three segments, longer pubescence on last segment, measurements: I, 10; II, 8; III, 54; IV, 15. Legs short, with femora only slightly swollen, the tarsi thin.

Pronotum wide, moderately broadly transversely convex across humeral angles, closely punctate; calli small, impressed, impunctate; collar distinctly raised, areolate, modified behind front margins so as to form there a very small subquadrate hood just in front of calli, the hood with a transverse veinlet across its crest; paranota moderately wide, biseriate, the areolae about the same size as in costal area; median carina extending from apex of triangular process to hood, low and without areolae on pronotal disc, then more elevated and with moderately large areolae in front of and behind disc; lateral carinae distinctly divergent anteriorly from the base of the posterior process, less elevated with smaller areolae on discal part of pronotum.

Elytra with sutural areas overlapping and jointly rounded behind in repose; costal area largely or entirely biseriate, sometimes with a few additional areolae in widest part beyond discoidal area, the areolae moderately large; subcostal area much wider than costal area, sloping obliquely downward, largely four areolae deep, with areolae smaller but about equal in size to those in discoidal area; discoidal area very large, seven-tenths as long as elytra, with outer boundary vein a little arcuate, acutely angulate at both base and apex, widest near middle, there eight areolae deep, with boundary veins raised and prominent; sutural area large, with areolae a little larger apically. Wings longer than abdomen.

Holotype (male), Saint George's Sound, Queensland. *Paratype:* One specimen, same data as on type label.

The long head, rather longly extended in front of eyes, and the long bucculae (apices slightly surpassing tylus) distinguish this insect from genus *Tingis* and other genera of the subfamily Tinginae occurring in the Australian Region.

Ulonemia pacifica (Kirkaldy)

Teleonemia pacifica Kirkaldy 1908 : 780.

Ulonemia pacifica Drake and Poor 1943 : 193; 1945 : 288.

Moven District, Queensland, iv. 1945, 27 specimens, N. Geary. This widely distributed species is also found on several islands of the South Pacific. As it is atypical of both *Teleonemia* and *Ulonemia*, its generic position will be discussed in a subsequent paper.

Ulonemia mjobergi (Horvath)

Tingis (Tingis) mjobergi Horvath 1925 : 5.

Ulonemia mjobergi Drake and Poor 1937 : 3.

Fuller's Bridge, Lane Cove River, New South Wales, two specimens, x. 1934, Dr. K. K. Spense; Sydney, New South Wales, one specimen. This species was originally described from Broome, Western Australia.

Ischnotingis horvathi Drake

Ischnotingis horvathi Drake 1954 : 69.

Sydney, New South Wales, one specimen. Originally described from New South Wales.

Epimixia tenuatis Drake

Epimixia tenuatis Drake 1944 : 71.

Clermont, Queensland, two specimens, 30, ix. 1929, Dr. K. K. Spense.

Epimixia veteris Drake

Epimixia veternis Drake 1944 : 71.

Cairns, Queensland, common on *Casuarina*, J. G. Brooks.

Tanybyrsa ampliata (Hacker)

Compseuta ampliata Hacker 1927 : 26.

Morven District, Queensland, six specimens, iv. 1941, N. Geary.

Caloloma uhleri Drake and Bruner

Caloloma uhleri Drake and Bruner 1924 : 153.

One specimen, probably from New South Wales. This species was originally described from the West Indies (Island Antigua, Lesser Antilles). Several specimens have been identified from Australia during the past decade, and only the type specimens are known from Insular America. There seems to be little, if any, doubt that *uhleri* is a native Australian species.

Stephanitis pyrioides (Scott)

Tingis pyrioides Scott 1874 : 440.

Stephanitis azaleae Horvath 1905 : 568; 1912 : 333.

Stephanitis pyrioides Drake and Maa 1953 : 101.

Lane Cove, New South Wales, five specimens, 26. iv. 1924, N.W. Rood. This is an imported species, probably from the Orient, Europe or the United States. It was originally described from Japan. It feeds and breeds on *Azalea* and *Rhododendron* species. *Pieris ovalifolia* also serves as a host in Formosa and Japan.

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Explanation of Plates

Plate III : *Dictyla amitina* (Horvath) (left) and *Dictyla aima* Drake, n. sp.

Plate IV : *Codotingis evansi*, n. sp.

Plate V : *Alloeocysta approba*, n. gen. and n. sp.

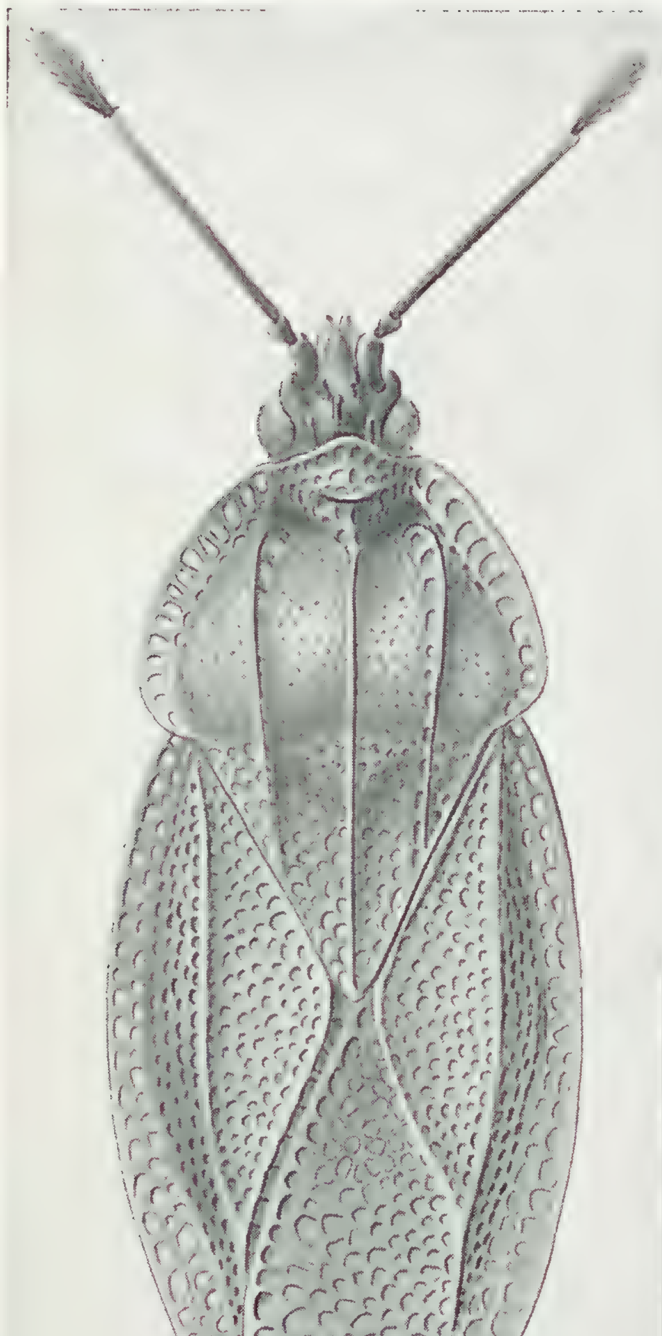
Plate VI : *Chorotingis indigena*, n. gen. and n. sp.

Sydney: V. C. N. Blight, Government Printer—1960


PJH.


PJH.

PLATE V


P.J.H.

A REMARKABLE RITUAL GALLERY OF CAVE PAINTINGS IN EASTERN NEW SOUTH WALES

By FREDERICK D. McCARTHY,
Australian Museum

(Figs. 1–71) (Plates 7–8) Manuscript Received 14.4.60

The rock shelter containing this extraordinarily fine set of drawings and stencils is situated in the Hawkesbury district on Crown land. Because of the need to protect the gallery from vandals its precise locality cannot be disclosed. For this reason, also, the Cumberland County Council has erected a thick wire screen across the entire front of the shelter.

The shelter forms part of the vertical face, about 8 ft. high, of an extensive sandstone rock surface which runs across the base of a marsh. A dozen potholes, 3 ft. to 4 ft. in diameter and up to 2 ft. deep, have been formed in the bed of the main flow of water, which runs in rainy weather and is usually seeping over the rock. Beside some of these pools are, in all, several dozen axe-grinding grooves.

The rock shelter is one chain west of the potholes. It is 60 ft. long, 9 ft. deep and high, and runs south-east to north-west. The sandstone is hard, dry and durable, and the drawings are in perfect condition. The front of the ceiling is blackened by fire-smoke, due mainly to bush fires burning scrub at the entrance to the cave. The shelter was not used by the natives as a camp site, but was of ritual importance to them.

The shallow loamy floor deposit contains specks of wood ash, and from it were recovered several small chert waste flakes, a quartz bipolar flake and a jasper microlithic side scraper, but none of these pieces is a specialized type of implement that can be assigned to a specific culture period. Pieces of ferruginous sandstone were also found, but none of them shows any signs of rubbing or use as red pigment. No ochres were present in the deposit.

The stencils were done with a water-mixed paint, but all of the other figures were drawn with dry pigment and are therefore referred to as drawings, not paintings. The series is described in six periods, revealed by a study of the superimpositions.

I. STENCIL PERIOD

There are 26 white, 19 red and one yellow human hand stencils the great majority of which are opened left hands. None was observed with the little or other fingers turned down. Most of the red hands are stencilled along a higher level than the white hands, but both occur along the full length of the frieze. Five stencilled boomerangs (Figs. 20, 29, 34, 38, 66) belong to this period, most of them being long and shallow curved types, 2 ft. to 2ft. 6in. long, but one is sharply angled with two distinct arms. A red line design has been drawn in dry pigment within the stencil of Fig. 20.

Other stencils comprise two hafted ground-edge axes (14, 58) 9 in. long, a club 13 in. long (19), and six small crescents from 5 in. to 8 in. long (67) of a kind not previously recorded.

All of these stencils were done with the splash method, in which paint was blown from the mouth over the object placed against the wall.

II. RED AND WHITE PERIOD

The forepart of a large kangaroo (22), and the complete figure of a short, broad man (30), both 3 ft. 6 in. long, apparently represent a hunting episode. When they were drawn the wall between them was blank. The kangaroo has a well poised head, and the drawing of one forepaw upwards and one downwards is exceptional, the usual style in the central coastal area being to show them as a pair at one angle or as a single limb.

Red Outline

A woman 2 ft. 3 in. long (60) and a faint human figure 3 ft. 6 in. long (69) are at the northern end of the shelter. Both lie horizontally in relation to the main frieze. There are also an oval line figure (24) and the hind portion of a kangaroo (65). Faded lines of other indeterminate figures in this style are to be seen in various places.

Red Silhouette

A partially shaded kangaroo, lacking tail, 3 ft. long (10). There is a smaller one in red outline below its neck.

Remarks

The broad heavy man, with well-marked penis, is probably a spiritual being, and the kangaroo one of mythological and ritual importance.

The association of stencilled boomerangs in the drawings and outline boomerangs in the engravings, with the kangaroo and other animals, is characteristic of the art of the central coastal area of New South Wales, and indicates an ancient usage of the boomerang for hunting in this well-forested and rugged country. Another link with the engravings is the drawing of a woman (60) in the outline style.

III. BLACK AND WHITE PERIOD

All of the black and white outlines and silhouettes belong to this period, and comprise the majority of the drawings in the gallery.

White Outline

Line figure (8); oval (13); tanged outline 18 in. long (35); mammal 17 in. long in upright posture (37); forepart of a wallaby (44); emu-like bird 2 ft. 9 in. long (47); human figure 21 in. long, holding weapon in one hand (50); koala 15 in. long (51); bladed club of Lil-lil type (52); white oval drawn around a faded emu (55); pair of conical objects (56); portion of conical figure (61); upper part of tortoise (62); elongate human figure 18 in. long (63); possum 3 ft. 7in. long (64).

White Barred

Upper part of a man (21) and a conical figure (41).

White Stripes

Most of these figures are covered with longitudinal lines drawn closely together, and some of them have faded into pale, white silhouettes.

Human foot 9 in. long (6); koala, facing frontwards, 8 in. high (7); two human figures 18 in. and 21 in. high (16, 17); boomerang, with broad end (26); human figure wearing rayed head-dress, portion of the figure being under 30 and 32 (31); echidna 18 in. long (49); a neatly drawn bird, like a goose, 15 in. high (55); oval (53); kangaroo 2 ft. 6 in. long, with thin hind limbs and a thick tail (59).

Black Outline

Throwing dart, commonly called the *weet-weet* (9); small kangaroo 21in. long, lacking its tail, beside a larger red and black one (10); ornaments, probably of kangaroo teeth, worn across the forehead and chest and around the neck—they appear to be too long, and the fringe too short, to be the fur-skin pubic aprons worn in this area (23, 54); line design, incomplete (28); seven of these ovals or circles are drawn around small weathered pits from 4in. to 6 in. in diameter and up to 1 in. deep—they probably represent a clutch of emu eggs (42, 57); portion of mammal (40).

Black Stripes

Two eels about 3 ft. long, and portions of two others (1–4); portion of oval (11); portion of mammal of echidna type (15).

Black Silhouette

Human figure 21 in. long (27); possum partially infilled, 16 in. long (36); man (45); upper portion of man holding shield (46); man (48).

There are several other faded and indeterminate figures in the same style which are probably men also. Some of these black silhouettes are faded and may originally have been black striped figures.

Black and White Outline

A rock wallaby, almost 2 ft. high, in an alert standing pose (12).

Black Silhouette with White Outline

A beautifully drawn little mammal, with long hind legs and tail, 21 in. long, like a rock wallaby in a leaping pose (18).

Black and White Stripes

A short thick-set man, 3 ft. 6 in. high, drawn with a white infilling on the head, arms, legs and very long penis, and a thick black outline (25). His stomach is mainly black, and although he is drawn over the stencilled boomerang (29) the white colouration around it has been left as the white infilling on his body. He is decorated with a double band of white lines, probably kangaroo-tooth chest ornaments, and is a figure of considerable power and strength, obviously more than of simple human significance.

Red and Black

A kangaroo 3 ft. 6 in. long (10) appears to be a red silhouette with a black outline, but it is now so faded that it is impossible to decide whether this is so or whether a red silhouette kangaroo has been drawn over a black outline one.

Remarks

The figures drawn in this period are mostly single and unrelated motifs, and among them several of the mammals and birds are well portrayed artistically. With the exception of the eels, they are forest creatures typical of the locality. The outline figures are identical in style with the outline rock engravings of the Sydney-Hawkesbury district in which the shelter is situated.

IV. POLYCHROME PERIOD

The only figure drawn in this style is an anthropomorph (32) 8 ft. high. Although it conforms in general style and striped technique with other human figures in the central coastal area, it possesses characteristics which make it unique among these pictographs. It is the first four-colour polychrome drawing to be recorded in the central coastal area. The figure is portrayed from the front. It is covered with white and bright-red stripes, and has a double black and yellow outline on the head, arms and right side of the body, black fingers and hand on the right arm, and a black outline on the hand and fingers of the left arm. Across the chest are two rows of short white vertical lines, similar to those on 25, which probably represent kangaroo-teeth ornaments[1]. The head is that of an indeterminate mammal, with two ears and eyes and a rounded face. In colouring the head, the artist has simply applied the red in several forward and backward movements to produce a series of loops. The end of the legs and thick penis are lacking, having been obscured by a layer of dust which has discoloured a concave ledge extending the full length of the shelter. This hero is holding a large boomerang or phacoid-shaped club in his left hand. The artist was forced to narrow the shoulders, because the concave area of rock wall on which he drew the figure decreases in width at this point and the figure had to be shaped to fit into it. Shoulders and arms are separated by a thick line.

The power and strength of this composite being are emphasized by the thick limbs and penis, the broad body and the large weapon with which he is armed. He is a striking example of the culture-heroes and spiritual beings holding a weapon, usually a boomerang, in the left hand, who are prominent in the mythology of Australian tribes (Elkin, 1950, 126–7).

This hero is depicted in the guise of a composite human being with a mammal's head, a type of ancestral totemic being featured in the *bora* mythology of south-eastern Australia generally (Howitt, 488–508). While no other figures of these composite beings are known among the central-coast drawings, a number of them has been recorded in the Sydney–Hawkesbury rock engravings. They include a combination of man and emu, and of man and mammal, in Kuring-gai Chase National Park (McCarthy, 1944, Pl.R, Fig.10, 1946, Pl.Z, Fig.3), man and emu on the Peter Howe Trust Reserve at Somersby (McCarthy, 1947, Pl. AD, Fig. 1), man and bird in the Berowra district, and snake-headed heroes at Calga. They represent both the totem and spiritual ancestor of a clan, and are depicted at sites at which historical and totemic rites were enacted. These rites included incidents in the lives of the spiritual ancestor, and possibly those for the increase of the totem.

There is the possibility that the three large human figures—in red outline (30), black and white (25) and red, black, white and yellow (32)—all represent portrayals of the same hero which became more elaborate in each succeeding period from the earlier red and white to the late polychrome periods.

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[1] A similar ornament is shown on the culture-hero in the Mt. Kuring-gai group of rock engravings (McCarthy, 1959, Fig. 1, Pl. 23). The design suggests a string of kangaroo teeth rather than a painted design.

V. BORA GROUND PERIOD

Fig. 5 is a remarkable design drawn in red across the full length of the gallery and over all of the figures in its track. It stretches for over 31 ft. and then turns back another 8 ft. 6in., so that it is almost 40 ft. in total length. Although the reversed end may be an integral part of the design, it is possible that the artist misjudged the length of the shelter and found himself without sufficient wall-space to extend the figure to its full length. At the northern end of the figure is an oval from which a long band, with a narrower one joined to it along the middle portion, extends for 28 ft. to a second oval joined to a third oval from which the band continues to a fourth oval at the end of the reversed portion. There is a second figure (39 and 68) of this type at the northern end of the frieze; it was 15 ft. long, but the band connecting the ovals has either weathered away or been obscured by the dusty layer which covers the ledge. These designs are coloured-in as red silhouettes by overlapping lines of dry pigment drawn thickly enough to merge into one another.

The designs probably represent *bora* initiation grounds, as described by Howitt (1904, Ch. ix), and by R. H. Mathews in his many descriptions of *bora* ceremonies in south-eastern Australia. The *bora* ground consists of two cleared and circular spaces, one for assembly and corroborees, the other for tooth-avulsion and other secret rites, joined by a path from a quarter to over a mile long. Thus we could interpret the two later periods, IV and V, of drawings in this shelter as representing a *bora* ground visited by a culture hero or spiritual ancestor in the guise of a mammal totem. Howitt said that a supernatural being, known as Daramulan on the southern half of the New South Wales coast, Koin on the north coast, and Baiami, Nurrundere, Bunjil, Nurelli, Mungan-Ngaua and other names elsewhere in south-eastern Australia, was represented by his native informants as having at one time dwelt on the earth, from where he went to live in a land beyond the sky to observe mankind. As Daramulan, he could go anywhere and do anything, become invisible and appear in the form of an old Aboriginal man. He is eternal and has existed from the beginning of all things, which he created. Elkin (1938, 201) said that this sky-hero was often pictured as the one who led the tribe to its present habitat, and made the natural features as they are today; he bestowed on men their material culture, gave them their social laws, and, above all, instituted the initiation rites. He was, as Howitt said, full of knowledge and tribal wisdom, all-powerful in, and the source of, magic. The medicine-man alone could see him on earth or visit him in his heavenly home. One of his important functions was to take the young men away and return them as initiates.

It is apparent that Fig. 32 in this shelter represents a sky-hero of the above type. Howitt (op.cit.) stressed the fact that the sky-hero or All-Father was always described by his informants as possessing human form. However, the examples given above of composite human and animal anthropomorphs among the rock engravings, and Fig. 32 in this shelter, prove quite clearly that such heroes could also appear, and were actually represented by the artists, in composite form varying with the totem concerned.

This cave would, therefore, have been a site of the greatest possible importance in the ritual and mythology of the local tribe.

VI. POST-WHITE PERIOD

Stencils of a boomerang (33) and of a hand (between 44 and 52) have been made in a series of circular daubs done with a rough brush or thick stick teased out at the end. They are unlike any other stencils known to me in the central coastal area, and were apparently the last figures added to the gallery, probably after white settlement by one of the full or mixed bloods familiar with the site. They indicate that the site was functioning in the life of the Aborigines living at the beginning of white occupation, and for some time afterwards.

COLOURS

Three basic colours—white, red and black—used by the Aborigines are well represented, the white in all periods except the fourth, the red in all periods except the second and fifth, the black in the second and third periods. Yellow was used on one hand stencil in the first period and on the sky-hero in the fourth period. Bichromes occur in black and white, red and white, red and black, and four colours in the sky-hero.

SUPERIMPOSITIONS

Examples of the superimpositions among these drawings are as follows: (1) Modern stencil of boomerang (33) over red *bora* design, which is over polychrome sky-hero, which is over white striped and red outline men, which are over yellow and white hand stencils; (2) red *bora* design (5) over red and white hand stencils, white outlines, striped and silhouette figures,

black silhouettes and striped figures; (3) red *bora* design over white silhouette, and man which is over white stencilled club; (4) black kangaroo tooth ornament (23) over red outline kangaroo (22) which is over white stencil; (5) black and white man (25) over red and white outline man (3) which is over white stencil; (6) white outlines and other styles, black outlines and other styles, over stencils in various places; (7) white striped boomerang (26) over black and white man (25) which is over yellow stencil boomerang.

The stencils are limited chiefly to the first or earliest period of painting, outlines and silhouettes occur in the second period, the widest range of styles are in the third period, striped in the fourth period, silhouettes in the fifth period, and stencils in the last or modern period.

SUBJECTS

The artists and other tribesmen concerned with this shelter were interested in a varying range of motifs in the different periods of stencilling and drawing. These motifs are human hands, boomerangs, clubs, axes and crescents by those who did the stencils; a human being (which might be a spiritual ancestor), kangaroo and oval in the second period; a spiritual ancestor, human beings, a wide range of animals which include the kangaroo, rock wallaby, koala, echidna, possum and other mammals, turtle, emu and its eggs, goose, eels, boomerang and club, throwing-dart, kangaroo-tooth ornaments and various simple designs in the third period; and a sky-hero and *bora* ground in the fourth and fifth periods.

DISCUSSION

This site confirms the interpretation of colours and superimpositions in the Conjola rock shelters (McCarthy, 1959), where stencil, red, black and bichrome periods were distinguished in that order, the stencils being the earliest phase. Although the stencilling is probably as ancient as any other technique and style of pictograph in south-eastern Australia, it must be remembered that stencils of hafted axes prove clearly that this technique was also practised in the Eloueran as well as in the Bondaian and probably earlier culture periods in this region (McCarthy, 1948). The two hafted axes (14 and 58) are not over or under any other figures to which their relationship can thus be decided, but one club (19) in a similar technique is under a white silhouette figure of the third period. The axe-grooves nearby indicate that the site was frequented in the Eloueran period.

Much more detailed investigation of superimpositions in cave paintings and drawings is necessary before relationships between the various cave art periods and the archaeological cultures such as the Eloueran axe period, Bondaian point and microlithic period, Kartan uniface pebble period and any other hitherto unknown culture period, may be established.

I have drawn attention above to similarities between outline drawings in this shelter and those in the outline rock engravings of the Sydney–Hawkesbury district generally, particularly in respect to the sky-hero (32). These massive heroes, with huge bodies and limbs, are well represented among these engravings, as shown by Campbell (1899, Pls. 6, 12, 16, 20, 22, 25) and McCarthy (1941–1959). A number of them are striped on the body and limbs. This kind of hero was fashioned in earth figures throughout the area of the *bora* type of initiation, and is similar to that of the Lightning brothers (Davidson, 1936, Pl. 1; McCarthy, 1958, frontispiece), and the Wandjina of the Kimberleys (Elkin, 1930). Thus, the depiction of heroes in a similar style, in both engravings and paintings in such widely distributed localities in northern and eastern Australia, indicates that the concept is of considerable antiquity and, further, that the decoration of the head is probably the main change that has taken place in the Wandjina style. This change in head form and features may have been due to introduced ideas, but more evidence has yet to be assembled before this point can be decided.

ROCK ENGRAVINGS

A fish (70) is engraved in a narrow conjoined puncture technique on the sloping base of the wall at the southern end of the cave. It is $21\frac{1}{2}$ in. long.

In the western end of the expanse of rock above the shelter is engraved a group of five figures, which comprise a koala 3 ft. 6 in. long (71, top left), an oval, two human or koala figures engaged in sexual intercourse (middle) and, 30 ft. away, a kangaroo 8 ft. long. The grooves consist of weathered conjoined punctures now from $\frac{1}{2}$ in. to $\frac{3}{16}$ in. wide and $\frac{1}{16}$ in. to $\frac{1}{8}$ in. deep. Its state of preservation indicates that this is an old group compared with others in the Sydney–Hawkesbury district.

It is notable that both kangaroos and koalas are included in the cave paintings at this site, in this group of engravings, and in another group a quarter-of-a-mile away. The shape of the head of the great hero (32) suggests either one of these mammals.

The similarities between the outline figures of animals and people, and between the sky-hero figures, in this shelter and the rock engravings of the Sydney–Hawkesbury district make it apparent that the people who practised the latter art contributed some of the paintings to the shelter, possibly a considerable proportion of them.

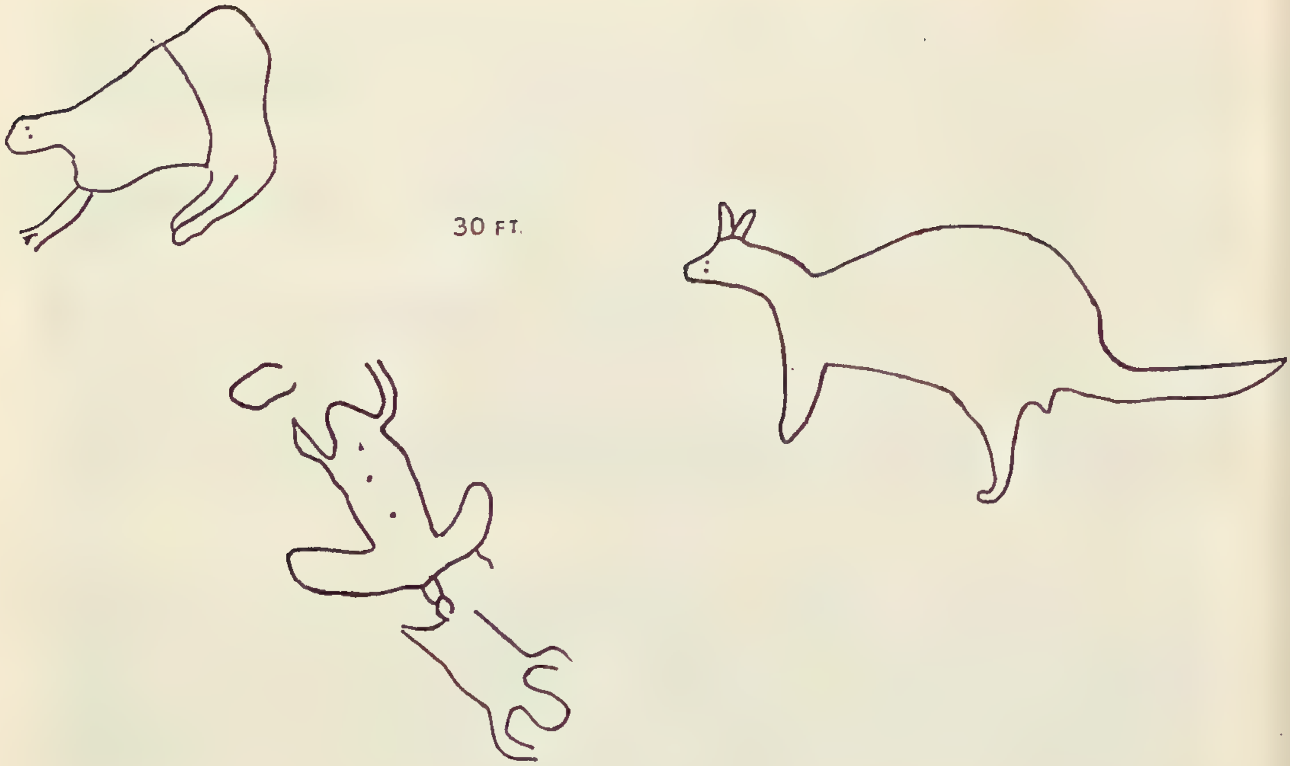

Fig. 71.

Acknowledgements

This site was first reported to the Museum in 1957 by the owner of the property beside whose boundary it is situated. A scale plan was made of the gallery by John Beeman, Australian Museum artist, and the author, and then Mr. Justice F. G. Myers made a set of colour negatives of the paintings which he presented to the Museum. The scale plan was compared with these negatives, with a set of enlarged black and white photographs taken by H. Hughes, Australian Museum, and with the paintings in the shelter. A final scale plan was then made by Miss Jannelle Bailey, technical assistant, Australian Museum. I have pleasure in thanking all of the above-mentioned for their assistance in building up the final recording, rendered as accurate as possible, of this very interesting and important Aboriginal art gallery, the Cumberland County Council for its constructive action to protect the site from vandals, and the owner of the adjoining farm for permitting access through his property to the site.

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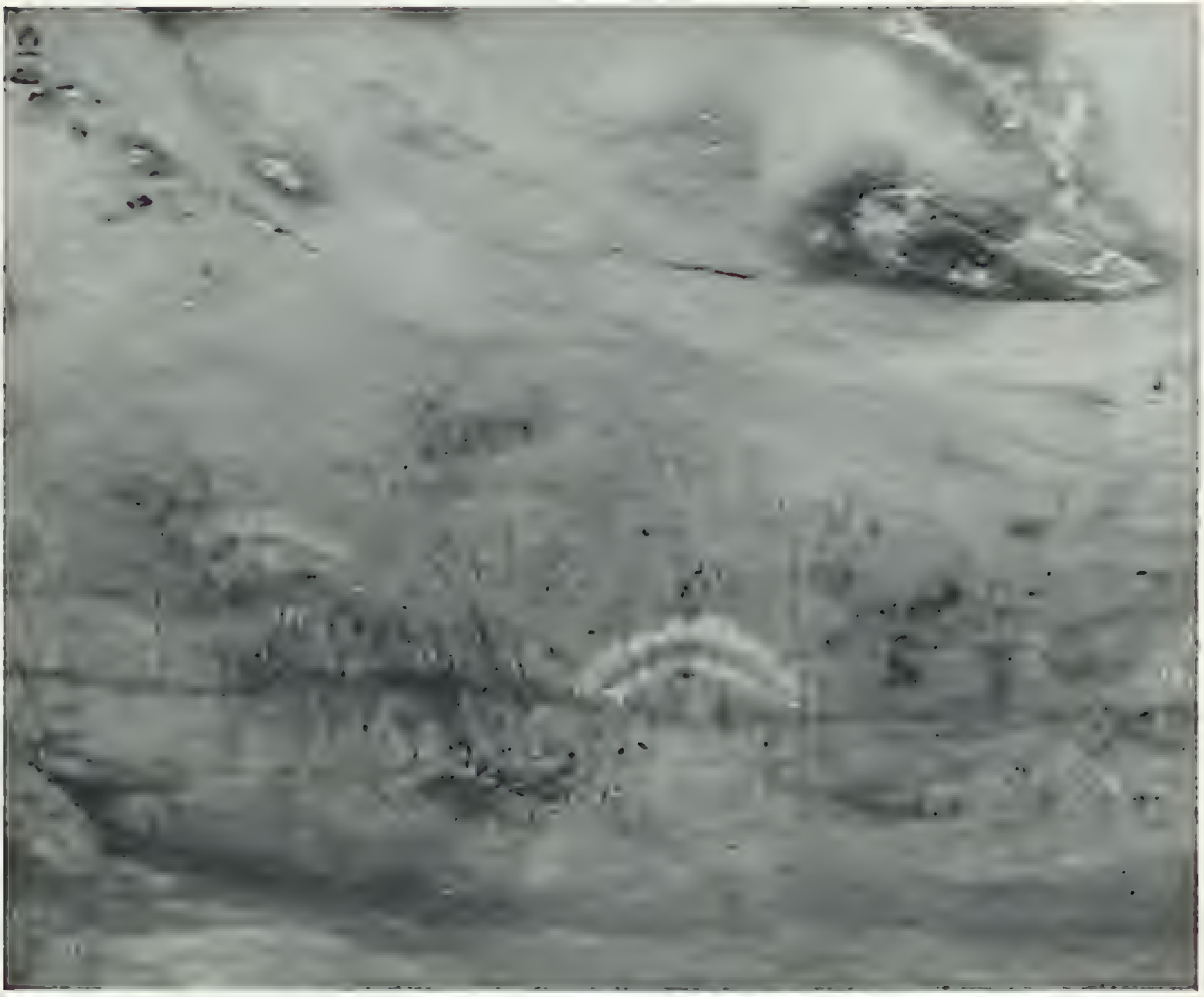
Explanation of Plates

Plate I.—Top: General view of site, with pools in foreground, area of rock in which engravings are made, and the rock shelter at the far end of the ledge. Bottom: Eastern end of the painted frieze.

Plate II.—Top: Middle of the painted frieze, showing the polychrome culture hero. Bottom: Western end of the frieze.

Sydney: V. C. N. Blight, Government Printer—1960



Figs. 1–70

THE ROCK ENGRAVINGS OF DEPUCH ISLAND, NORTH-WEST AUSTRALIA

By FREDERICK D. McCARTHY,
Australian Museum

(Figs. 1-292) (Plates IX-XV) Manuscript received 14.4.60

Depuch Island was named by the Baudin Expedition (Peron and Freycinet, 1824) in 1801 in honour of Louis Depuch, mineralogist of the expedition, who died at L'Ile de France in 1803, the year in which the Forestier's Archipelago was discovered and named. It is by far the most prominent island in the archipelago, all of the others being low and sandy. M. Ronsard, the engineer, spent almost a week examining Depuch Island, which he recorded as being in lat. 20° 35′ 30″, and long. 115° 12′ 50″, and between four and five miles in length.

None of the scientists were allowed to accompany him or to land, and this omission probably explains why the remarkable series of rock engravings was not noted by the expedition. Ronsard remarked on the columnar basalt structure of the island, with the prisms lying at all angles and, in some places, forming pavements. The colour of the rock he noted to be bluish grey, and the texture very fine and compact. Only one quadruped was seen, which was thought to be a dog, and one of the seamen saw a small kangaroo[1]. A few kinds of flycatchers and waterfowl were seen, and also a brown serpent, about 5 ft. in length, of the boa kind. Various insects and shells complete the fauna recorded on the island. A small quantity of ferruginous water was obtained from hollows, where beautiful shrubs and trees formed pleasant groves; elsewhere there was absolute sterility. Ronsard was impressed by the melancholy and monotony of the island, and the discomfort of the walking. No natives were seen, but fireplaces and newly-broken pieces of basalt proved that they visited the island.

H.M.S. Beagle was the next vessel to visit Depuch to obtain water. Captain Wickham (1842, whose description was republished by Stokes in 1846) said the island was a vast pile of reddish-coloured blocks, eight miles in circumference and 514 ft. high, with an even silhouette from seaward. Mr. Bynoe, from the Beagle, found a reservoir of water in the main valley, called Watering Valley by Wickham, which runs into the heart of the island from the northern end of Beagle Beach. As no rafts[2] were seen in this area, it was presumed that the natives walked[3] across the sandbanks at low tide to visit the islands, of which Depuch appeared to be their favourite resort, to secure turtles and fish. Several huts were seen on the island, but no natives, and those observed on the nearby mainland fled immediately an attempt was made to approach them. Another purpose of their visits was to " exercise their talents for drawing representations of whatever they had seen upon the flat surface of the rocks. This they do by removing the hard red outer coating, and baring to view the natural colour of the greenstone according to the outline they have traced ". Thirteen figures were published out of the 94 listed, and apparently drawn, by Wickham, who took an unusually keen interest in this art during " many an excursion over that dreary heap of desolation ".

Depuch Island, called Womalantha by the natives, is situated between Port Hedland and Roebourne (in Nickol Bay) on the north-west coast of Australia. It is opposite the " ghost " port of Balla Balla, which is now almost completely obliterated. Peawah Hill, some six miles to the south on the mainland, and on which are some engravings I did not have time to record, is a similar igneous outcrop. The rock is identified as an epidiorite or altered dolerite (David's geological map of Australia).

There are several fine sandy beaches on the island. Petri and Schulz (1951) said there was no water there, but it is available in small pools along the rocky shore above high-water mark, particularly on the southern side of Anchor Hill, directly below the engravings. An abundant supply is available from large pools in Watering Valley. The island was declared a sanctuary in 1958 for the protection of the engravings and fauna.

Smyth (1878, I, 292-3, figs. 44-46) mistakenly described the art as that of painting, an error repeated by Mathew (1893, 42). Mathew (1895) obtained information from Messrs. A. A. Hall and W. Byron about the art which corroborated Wickham's original account. Davidson (1936, 1952) discussed the techniques, styles and subjects, and McCarthy (1958) referred briefly to them.

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[1] Both were probably rock wallabies.

[2] Richardson (1886, 298) said the natives of this area sat " astride " a log of wood and propelled it with their hands.

[3] Depuch Island cannot be reached in this way at present, owing to a deep channel along the southern shore.

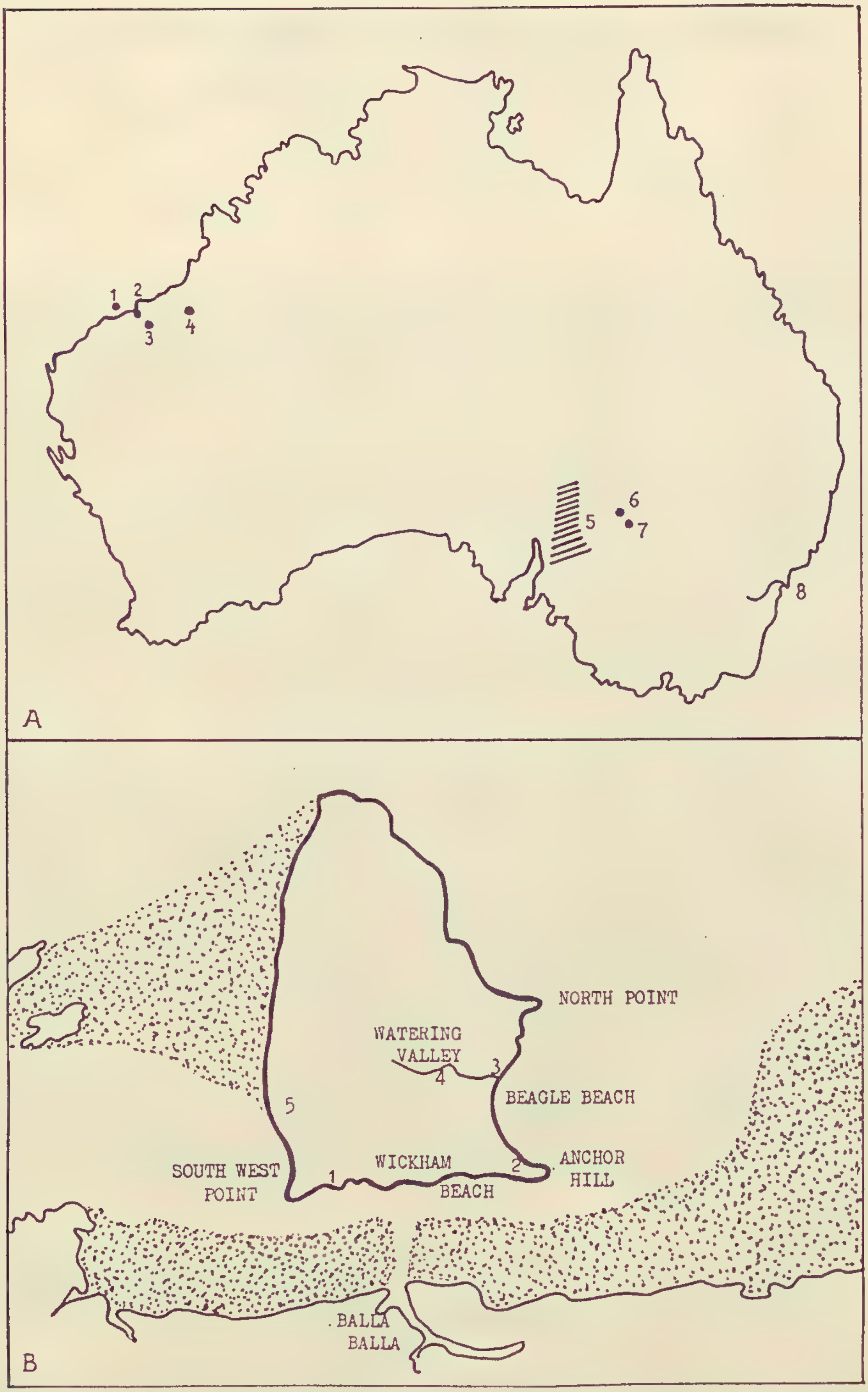

Fig. 1.A. Sites of rock engravings in Australia mentioned in this paper: 1. Depuch Is. 2. Port Headland. 3. Wamerana and Gallery Hill, Abydos. 4. Mt. Edgar or Mentheena. 5. Flinders Range. 6. Sturt's Meadows. 7. Mootwingee. 8. Sydney-Hawkesbury District. B. Diagrammatic map of Depuch Is., showing localities where engravings were recorded, all in the southern portion nearer the mainland. North Point, Watering Valley and Anchor Hill are old-established names, but Beagle and Wickham Beaches and South-west Point are names adopted in this paper to facilitate reference to these places.

The first scientific party interested in rock engravings to visit the island included the German anthropologists, Drs. H. Petri, A. Lommel and D. Fox (1951), from the Frobenius Institut, in 1938-39, who recorded figures on the southern shore and Anchor Hill (on which a stone cairn for navigation is situated). They stated that these engravings surpassed in careful execution and variety and richness of groups and compositions most of those known elsewhere in Australia, and previous writers were impressed by the immense number, high artistic quality and unusual nature of these engravings. They said that animals of the land and anthropomorphs were dominant, some insects were represented, and, as the marine fauna was in an overwhelming majority, the art belonged to a " saltwater " tribe.

During a trip to north-west Australia, financed by the Wenner-Gren Foundation for Anthropological Research, I visited the island twice in 1958 with Mr. A. Day, Native Welfare Officer at Port Hedland, accompanied on the second occasion by a party from Mundabullagana Station. A total of five days was spent on the island. During these visits I photographed engravings along the southern shore, on Anchor Hill, at the northern end of Beagle Beach, and in Watering Valley. Members of the party saw carvings elsewhere on the island, but we could not record them. In 1959 Mr. Day found a fine series on the south-west coast, of which he kindly sent me photographs to enable me to include the motifs in this paper.

The engravings were called *mani* by the Ngaluma tribe (Worms, 1951, 1072), in whose territory the island is situated. Their country of some 2,500 square miles of stony hills and spinifex flats extended for over 30 miles along the coast in the Nickol Bay area and 70 miles inland. They lived (Harper, 1886; Richardson, 1886; Withnell, 1901; Clement, 1904) by hunting, fishing and collecting plant foods, among which cakes of ground grass, acacia and mangrove seeds were an important item. They employed bough fences, spinifex grass fibre nets, stick frames and pits in hunting. The country was occupied in 1864 by white settlers. An epidemic of smallpox decimated the tribes of this region in 1865 and 1866, and it is probable that active interest in their ritual and rock art was seriously affected by the loss of many of their totemic clan headmen. Gold and other mining activities from 1880 onwards further disrupted tribal interests, and there were only 60 of the Ngaluma left when Radcliffe-Brown worked among them in 1910. The tribe is virtually extinct today.

DESCRIPTION OF ENGRAVINGS, FIGURES 2-346

In the following description the figures illustrated will be described in numerical order, with cross-references between the line drawings and plates. A discussion of the figures, techniques, styles, superimpositions and antiquity, meaning and function, artistic merit and comparison with other sites will follow.

Human Beings and Their Activities (See also 302-12, 314-6, 325-7, 329, 332, 337, 340-1, 343)

Fig. 2. Deeply grooved composition of large man, wearing five radiate ornaments on his head, armed with a shield and hooked boomerang; beside him are two boomerangs, a scalloped line and two small stickmen.

3. Intaglio of man.

4. Human figure, with a large bulbous projection between the legs which may be a female genital organ or a pubic apron. Crudely pecked intaglio. (Wickham, 1842, fig. 92.)

5. Pair of men, in outline, one of whom is holding a small mammal. Each has a long tapering penis. There are two boomerangs in the composition. They are engraved in a very prominent rock on the top of the southern side of Watering Valley, are well preserved, and in the same style as 127, 166 and 170. (Wickham, 1842, fig. 94.)

6. Pair of large and small human figures.

7. Small man.

8. A small stickman between two human figures, each with a large bulbous projection between the legs which may be a female genital organ or a pubic apron. Petri and Schulz (1951, fig. 10) thought them to be half-human and half-plant because of the radiate head-dresses.

9. Elongate figure of a man, showing testicles and long penis. Petri and Schulz (1951, fig. 9) suggested that it represented a man with a fish's tail.

10. Enigmatic composition, incorporating a human figure at the top.

11. Barred outline human figure.

12. Figures representing sexual intercourse between man and woman.

13. Well preserved intaglio of a turtle pecked over a weathered outline man.

14-19. Men of various types, of which 17 is well preserved, 15 is crudely pecked (like 337) and the others weathered. From 8 in. to 1 ft. long.

20. Composition of a large and animated figure of a woman and four small human figures. The widespread legs, and the small figure connected with the genital organ, indicate that this intaglio represents human reproduction, an unusual but important theme on this island. Worms (1951, 1077) recorded an engraving at Wamerana of a woman, with four very small human beings rather indistinctly engraved beside her as though they had just left her womb.

21-24. Pairs of human figures, in each of which is a large and a small figure. The figures in 21 to 24 probably represent the two brothers so prominent in north-western Australian mythology. 21 is well preserved, the others slightly weathered. From 8 in. to 15 in. high.

25. Enigmatic composition of an animal-like figure almost 3 ft. high with elaborate pendant decorations at top and bottom, joined by an upper limb to a little man armed with two boomerangs; above him is another man with a knobbed head ornament, and there are two pubic aprons, a turtle and a little man in the group. Petri and Schulz (1951, fig. 8b) thought this figure (and also 9) might represent a dugong with human attributes, because legendary salt-water creatures, which include sharks, dugongs and stingrays with human qualities and supernatural powers, form part of the mythology of Dampierland and other tribes of the north-west coast (Petri, 1939, 217).

26, 28-9. Stickmen fashioned by overlapping longitudinal incisions done with a sharp tool, such as the edge of a shell. They vary from weathered to well-preserved figures.

27. Man.

30. Pair of indeterminate creatures, each of which has a pair of short fore-limbs and thick hind limbs (or tail). One has a penis and a long ear-like projection on the head, and one has a bird-like mouth. They resemble penguins, but this bird did not inhabit the north-western coast.

31. Animated pair of human figures, with pear-shaped object. The larger figure appears to be a woman with a large bulbous genital organ.

32. Animated pair of human figures, in a pose which may represent sexual intercourse or a ritual dance.

33. Human figure, with neatly arranged hair (each strand of which is knobbed on the end like that on the Wandjinas of the Kimberleys) and a leaf-shaped appendage at the bottom which may represent the genital organ of a woman. The figure as a whole may be a composite design of human and animal, or may represent human birth.

34. A small man beside a large man wearing a knobbed ornament on his head. The big man is posed beside an outline stingray, and appears to be holding it, but as the intaglios and outlines belong to different periods of engraving the association may be fortuitous.

35. A hollow-bodied man, similar to those in the paintings of Napier Broome Bay recorded by G. Hill (Mountford, 1937) and Conjola, New South Wales (McCarthy, 1959, fig. 4, I).

36. Linked series of 10 little men.

37. Set of two little men, who appear to have been speared, between an indeterminate figure on the left and a bird track on the right.

38. Group of six unusual human figures, most of them armless.

39-40. Intaglios of human feet. This motif is not common on the island, and not more than three feet in a line were noted (see 238, 280 and 312). One foot beside an animal in a hunting composition is customary (see 100-1, 116). As it occurs in the outline, outline with lightly-pecked interior, and full intaglio styles, the human foot has been a motif throughout the period of engraving on the island. It is usually bigger than natural size and more toes than normal are common.

41-7, 50-1, 53-4 (also 312). Compositions of little men fighting with spears. The spears have plain or barbed heads, the barbs comprising a single row of from six to about 50. Some of these men carry a shield, and in some of the sets from one to three spears are shown piercing a man. The sets vary from weathered and faded to well-preserved, and include crudely pecked figures.

48. Elongate human figure between two tiny stickmen, with a long plain spear beside them.

49. One of several remarkable figures of a little man throwing a boomerang. This one is also armed with a shield.

52. Tiny man armed with spear and shield.

55-60. Sexual intercourse between man and woman. In three of the groups the woman has a large bulbous genital organ, and four of the figures are wearing pendant head ornaments. In 56 there is a set of three long thin arcs on each side of the man. 57 is weathered, but the

Figs. 2-40

others are well preserved. The curved penis extending from the man to the woman in 55, 58 and 60 is a device used in this subject among the Sydney-Hawkesbury engravings in eastern New South Wales (Campbell, 1899, pl. 24, fig. 4).

61. Man, with huge boomerang and lizard. The pecking on the boomerang is in close longitudinal rows.

62. Little man, wearing head-dress, pecked over an old outline turtle and boomerang.

63-67 (also 314). Men armed with boomerangs and shields. Similar portrayals occur at Mootwingee, in western New South Wales. They vary from weathered to well-preserved figures.

68. Man with lines attached to his body.

69. Stickman, wearing pubic apron, in the act of throwing a boomerang, and holding one in the other hand.

70. Little man, with cross on his head, holding two boomerangs.

71. A crudely pecked group of five little stickmen with large heads.

72-75. Men carrying indeterminate oval objects on their heads. The projections at each end of this object may be the flippers of a turtle, an important food and motif on the island, but the object may be of ceremonial or other meaning. The motif is an old one as the figures vary from a weathered to a well-preserved state. The thunderman featured in the bark paintings of north-eastern Arnhem Land carries an oval object on his head in a similar manner (Aust. Mus., E. 59913).

76. A large boomerang and two men, with a pubic apron below one of the latter, crudely pecked. (Wickham, 1842, fig. 16.)

77. Man and linear design.

78. Set of five men, each of whom is wearing a pendant head decoration.

79. Small intaglio figure of sexual intercourse between a man and a woman, beside a striped shield.

80. Man beside rounded object.

81. Group of five little men.

82. Man carrying a bag-shaped creature on his head.

83. Group of three types of human figures.

84. Little man with pair of boomerangs.

85. Man and boomerang.

86. Small group consisting of an indeterminate animal (left) and man (right, with a decorated penis), between which are several bird tracks, part of a boomerang, a set of parallel lines and a man or lizard.

87. Composition of stickmen and other figures.

Hunting Compositions

88. Vertical set of three boomerangs, with anthropomorphic figure, beside a speared turtle.

89. Indeterminate group, which includes a small man and a spear.

90. Small man hunting large turtle.

91. Set of two intaglio men beside a large bandicoot-like mammal fashioned with a series of pecked gashes in longitudinal lines.

92. Two little men and a woman, intaglios pecked over a large barred outline turtle speared by a tiny man. The spearing episode was the original subject, over which the intaglios have been done.

93. Bird catching one of two fish.

94. A dingo, 18 in. long, with ball-like feet characteristic of this animal in Aboriginal art, catching a curlew. (Petri and Schulz, 1951, fig. 12.)

95. Man spearing animal.

96. Three tiny men spearing a large fish, with a small fish above.

97. Indeterminate outline creature, and a little man with a long spear or line.

98. Little man between large boomerang and conical object.

99. Two little men spearing a large dolphin.


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Figs. 41-85

100-1. Deeply grooved outline tracks (like 325) of a bird hunted by a man.

102. Man and snake, lightly and crudely pecked.

103. Bird, with three of its tracks and three human tracks, lightly pecked.

104. Line of six little stickmen over which a large round figure has been pecked; beside them is a linear design and a big-headed man.

105. Three parallel rods above a boomerang, two small animal and three large bird tracks.

106. A group of four turtles and eel-like figures.

107. Nine little stickmen beside a large intaglio fish.

108. Man, with a fish and outline turtle.

109. Five little men, one of them armed with a boomerang, killing a bird. One figure appears to be two little men joined by their legs. In the composition are also to be seen a large boomerang, and four fringes. This extremely interesting group was illustrated by Wickham (1842, fig. 30), who thought the central figures depicted a man in a hut. The lines are engraved over part of the man, and it may represent a hunter concealed behind a screen awaiting his opportunity to kill the bird. It will be noted that the ends of the uprights on the screen project slightly above the bar (to which they are bound), whereas in all of the pubic aprons among the engravings on this island there is an even finish along the top strand. Withnell (1901, 19) said the natives erected two semi-circles of boughs around a waterhole, and drove kangaroos into a net suspended at one of the two openings.

110. Set of hind and foot tracks of a kangaroo or rock wallaby.

111. A little man holding a shield, with a curved object over his legs, standing beside a large oval object.

112, 114. Boomerangs beside the prints of the fore and hind limbs, and the tail, of a kangaroo or rock wallaby sitting down in sand or soft soil. This motif occurs at Yarlarweelor (Stokoe, 1959, pl. 26), Port Hedland, Mootwingee, Sturts Meadows and Flinders Ranges, and is characteristic of the Intaglio period.

113. A man with lines radiating on all sides from his body, surrounded by five smaller men, one of whom appears to be throwing a spear with a spearthrower. Deeply grooved.

115. Man between boomerangs, beside bird tracks and circular figure. Deeply grooved.

116. Outline human track beside an intaglio turtle.

117. Man killing a rock wallaby with a boomerang, a pair of the animal's tracks beside its head.

118. Decorated man beside a bird.

119. Lizard and bird with open beak.

120. A barbed line across an outline turtle.

121. Two small men, with triangulate heads, beside a barbed spear and a pair of large boomerangs.

122. Rock wallaby with a spear in its back.

123. Little man with a vertical set of three boomerangs above his head, and a bird.

Mammals. (See also 88, 91, 93-5, 117, 122, 300-1, 308, 317, 322, 327, 345).

124. Indeterminate animal with knobbed ornament on head.

125, 130, 132. Indeterminate animals.

126. Kangaroo or rock wallaby, poorly proportioned. Crudely pecked.

127. An unusually fine line figure of a kangaroo or rock wallaby, with intaglio feet. Similar to 5, 166 and 170 in technique.

128. Rock wallaby.

129. Jumping mouse. Lightly pecked. (Petri and Schulz, 1951, fig. 13.)

130. Possum-like mammal.

131. Rock wallaby, with a heavy outline and lightly-pecked interior.

132. Indeterminate mammal.

133. Rock wallaby.

134. Kangaroo's hind-foot track.

135. Pair of kangaroo's hind-foot tracks.


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Figs. 86-123

Birds (See also 318-320, 327, 340, 345).

136-7. Sea Curlew.

138. Emu, body lightly and legs completely pecked.

139. Great-billed Heron.

140. Beach Stone Curlew.

141. Portion of bird in outline.

142-143. Sea Curlew, body lightly and legs and head completely pecked.

144. Ibis.

145. Nanking Night Heron.

146. Portion of large, long-legged bird.

147. Small emu.

148-151. Clutches of birds' eggs. They are all well-preserved, and 151 is patchily pecked like 326. At Port Hedland and elsewhere on the mainland these clutches of eggs are often associated with emus' tracks, and the number of eggs in each set is less. There appear to be too many eggs in some of the Depuch Island clutches for the emu, and there is a possibility that some of them may belong to turtles.

152. Large bird tracks. These are scattered throughout the engravings, in from weathered to perfect condition. They do not occur in long series.

153. Bird-like figure.

Insects

154. This strange creature is one of the most beautiful rock engravings I have seen in Australia. It is now a weathered pale green figure on Anchor Hill. When originally engraved the pecking removed the thin red patination of the rock, and revealed the bluish-green rock beneath. A similar figure in an outline dotted style occurs at Gallery Hill, Abydos (Worms, 1954, pl. IVb). They are, in my opinion, engravings of the praying mantis, about which a legend was recorded by Love (1936, Chapt. XII) among the Worora. Petri and Schulz (1951, fig. 11) thought the Depuch Island figure represented a horned animal, or a dancer wearing an antler-like ornament on his head in a totem rite.

Amphibia (See also 333, 337, 343)

155. A Njangumada man told me that a similar figure to this among the Port Hedland engravings represented a species of " hill " lizard. The main design apparently depicts sexual intercourse between lizards, with a third figure at the bottom which suggests, in addition, the idea of birth.

156-60. Lizards of various kinds. The two stalked appendages, and fringe, may be on the head or tail of 157. They vary from weathered to well preserved.

161. Young frog.

Snakes (See also 197-202, 330, 332, 344)

162. A snake, with a stickman, and a bigger man with well-defined fingers, toes and hair.

163. Man with snake, which he appears to be holding.

164. A " fat " goanna. In heavy outline, with crudely pecked interior.

Fish and Marine Mammals (See also 328, 334, 336)

165. Sawfish and another fish.

166. School of young fish (intaglios), with a large outline oval figure.

167. Dugong above two sperm whales.

168. Indeterminate species.

169. Dolphins.

170. Indeterminate species. The outline technique is the same as that in 5 and 127.

171, 174, 178. Indeterminate species. Some are weathered and others well preserved.

172. Trevally.

173. Tiny man with spear against belly of large sperm whale.


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Figs. 124-164

175. Shark.

176-7, 179. Sperm whales, one of which is spouting. Lightly pecked.

180. Indeterminate species, in broad outline band style.

181-4, 185-7, 190. Indeterminate species. Several of these figures are lightly pecked, and 185 is partially pecked over older indeterminate figures. Most of them are well preserved.

188-9. Sawfish.

191. A set of five stingray livers, all engraved much larger than natural size. There is a small man beside one of them, and a tiny intaglio of a stingray is also shown. Some are lightly and others completely pecked, and they vary from weathered to well preserved.

192. Two outline stingrays, one of which has a weathered grooved outline, the other a lightly pecked outline.

Invertebrates (See also 324, 342)

193. Two large mangrove crabs (one is Wickham's, 1842, fig. 65).

194-6. Three indeterminate bag-shaped creatures. They are all lightly and sparsely pecked, and some of them may be beche-de-mer.

Snakes (See also 162-3, 330, 332, 344)

197. Python catching rock wallaby.

198. Python.

199. Man, with pair of large boomerangs, from whom a snake extends in a sinuous loop which encloses a little armed man.

200. Two snakes.

201. Coiled snake.

202. A sinuous snake beside two little men, who are wearing radiate and cross-type head-dresses, and another small figure.

Turtles (See also 90, 116, 105, 108, 297-9)

203, 230. Outline, with lightly pecked interior style. They vary from weathered to well-preserved.

204-5, 207, 211-2, 214, 216, 231. Intaglios. The large foot on 204 (the rock has broken away, carrying the other foot), the men spearing turtles in 207 and 231, and the swimming postures of 212 and 216 are notable. (212 is Petri and Schulz's 1951, fig. 15.)

206, 217-8, 224. Outline with barred or gridded interior style. A little man is spearing the large turtle in 224, which is deeply grooved.

206, 225. Outline with dotted interior style, with the two in 206 in swimming posture, while 225 is poorly shaped.

226-9. Female turtles containing eggs. 226 has two sets of flippers and tail, and 229 is between a man and a boomerang.

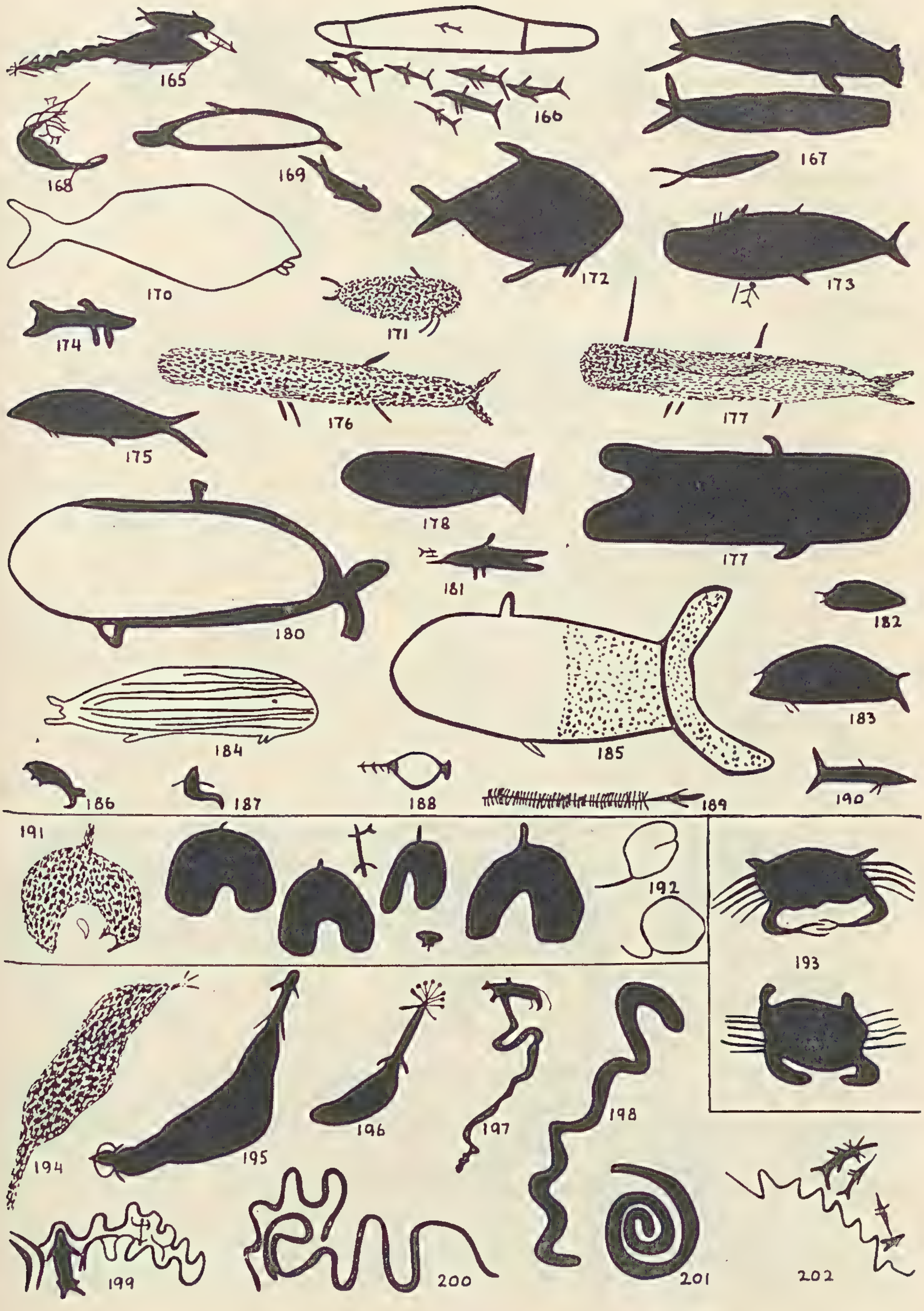
208-10, 213, 215, 219-27. All in the outline style, with solid flippers, head and tail. Two of them are captured by little men, one has a median line down the body, and two have a broad intaglio as an outline. The beautifully portrayed swimming action of the two turtles in 221, and the tiny little men beside the two large turtles, are noteworthy. Similarly, 205 (also 299) is engraved on a sloping rock in a pose of swimming downwards through the water.

222-3. These bear line designs of an unusual kind; 223 was probably intended for a turtle, and is lightly pecked.

231. A lightly pecked intaglio with solid head and flippers, and heavy outline.

Weapons (See also 2, 41-70, 76, 85-122, 199, 207, 224, 228, 231, 275-7, 312, 314-6, 322, 324, 327, 335-6, 343)

232. Boomerangs of various kinds, mostly from natural to larger size, some being about 3 ft. long. They vary from slender to broad kinds, and include a sharply-angled form. A throwing stick (top middle), and two boomerangs with a knob on the outer edge, are included.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Figs. 165-202

Pubic Aprons (See also 76, 109, 345) **and Ornaments.**

233. Selection of the varieties of aprons shown among the engravings.

234. Fringed ornament.

235. Little man wearing fringed ornament.

236. Grid design of kind painted and incised on chests of men.

237. Fringed radiate ornament, deeply grooved.

Radiate Designs

238. Composition of radiate and human figures, with human feet.

239. Unique variety of radiate figures.

240. Large radiate figure.

General

241 to 292 comprise motifs of an indeterminate or miscellaneous type, and others found by Mr. Day which could not be fitted into their proper groups in the line plates.

241-4. Seaweed-like figures, lightly pecked. A similar motif occurs on Chasm Island in a red silhouette painting (McCarthy, 1960, pl. 3D.)

245. The only series recorded of a set of inverted U-figures, a well-known motif in Central Australian art.

246-52. Indeterminate, varying in their state of preservation. 250, 252 are crudely pecked.

253. Oval shield with zigzag design. Only example recorded. Lightly pecked lines.

254. Pair of ovals with median line.

255. Fringed oval or insect.

256-7. Linear designs.

258. Indeterminate insect-like figure.

259. Man and indeterminate object. Lightly pecked.

260. Indeterminate bag-shaped figure.

261. Line design. Deeply grooved.

262. Indeterminate design.

263. Linked ovals.

264. Line design.

267-8. Pairs of objects resembling *kurdaitja* shoes, showing the upper webbed covering of the feet and the lacing. Such objects could well have been traded to the Indjibandi tribe along the same route as the hooked boomerangs and *tjuringa* which came from the Central Australian region through the desert country to the south. Skin and bark sandals were used to the south of the Indjibandi (Davidson, 1947). The fact that they are shown in pairs favours their interpretation as *kurdaitja* shoes or sandals, and not shields or sacred boards.

266. Set of four arcs. These occur in various localities on the island, and vary from a weathered to a well-preserved state.

269. Insect-like figure.

270. Double circle, which occurs in several localities, but is uncommon and unusually well preserved.

273-4. Designs; 273 has shallow, and 274 deep, grooves.

275. A series of over 45 little stickmen, some armed with a spear, standing in a circle around two sets of parallel lines which run from a central line. The significance of this group is unknown.

276. Battle between a dozen or so tiny stickmen armed with boomerangs. Two of them are wearing head-dresses, and among the men is a zigzag line. Lightly grooved.

277 (see also 311). Another series of tiny stickmen, some armed with spears, each standing at the end of lines radiating from the centre to the circumference of a circle. Some larger human and other figures are clustered together in the middle of the group, and on the right is a large bird track between other men. The significance of the group is unknown. (Wickham, 1842, fig. 16.)

278. Man with unusually large hands and feet.


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Figs. 203-240

279 (see also 339). Group of about 28 little stickmen with very large heads, among whom are seven others, each carrying an oval pronged object, and two lizards.

280 (see also 312). Outline human feet, with 7, 9 and 12 toes, and a little man. A similar set in 312 has five and six toes.

281-2. Ovals. These occur in various localities, but are uncommon.

283. Feather-plume hair ornament. Five of these are worn by the large man in 2.

284. Indeterminate.

285. Stickman under intaglio fish.

286. Emu track at end of design.

287. Indeterminate figure.

288. Eel-like figure, with stickmen at each end.

289. Elongate oval figure, with stickmen at each end.

290. Pair of elongate ovals.

291. Simple cluster design.

292. Catlike mammal. Lightly pecked.

Plates

293. Beagle Beach at low tide. A gallery (fig. 1B, No. 3) of engravings is located on the vertical and horizontal rocks in the middle distance, at the northern end of the beach.

294. Portion of the gallery on Anchor Hill, at the northern end of Beagle Beach. 25 and 288 are shown in the photograph, and there are many fine engravings in this area. Some have been obliterated by sea birds' dung.

295. Watering Valley, looking towards the sea. Note the big waterholes in the rocky bottom. A great number of engravings are depicted on the boulders along both sides of the valley.

296. Some of the engravings, including 94 and 212, on the boulders on the foreshore of Anchor Hill. Note the striped shield on the vertical rock in the middle background.

297. Old engraving of a large turtle in barred outline style done on a ridged convex rock to incorporate the shape of the animal in the portrayal. This is the only example noted of a contoured engraving, all of the others being in a flat plane.

298. A very old engraving of a large turtle on a cracked boulder at the northern end of Beagle Beach.

299 (see also 210). An artistic portrayal of a turtle engraved on a concave sloping surface of a boulder on the foreshore near the western end of Wickham Beach. It is in outline, the two hind flippers and tail being rubbed or abraded. Lightly grooved.

300. Jumping mouse.

301. Rock wallaby, with spear in belly, in outline with dotted interior style.

302. Indeterminate intaglio of a fish-shaped figure with long hair, small head with one ear, long neck and body with two small fins, and indistinct lower end. There are two rod-like projections from the head, and one from the neck. It may represent a composite human and fish figure.

303. Woman with long hair and well-marked hands and feet, but no breasts, giving birth to a child. Lightly pecked intaglio.

304. Fish-like figure, with pendant head-dress; joined to its tail is a turtle-shaped figure, from which another series of knobbed pendants extend. Apart from the head and tail attachments, the main figure resembles a dugong or dolphin with the two lower fins projecting like arms from the sides of the body. The main figure in 25 is similar, but it has no head, and the pendant head-dress rests directly on the top of the neck. The attachment on the lower end of the oval body is an openwork design of similar shape to that of 304. These are apparently spirit or mythical creatures of some importance. (Petri and Schulz, 1951, fig. 8a.)

305. Man and woman engaged in sexual intercourse. Although at first sight this figure suggests an insect with six legs, it will be noticed that the top is a man with rayed hair or forehead ornament, short arms, and large human feet on his straight legs. The woman is an undecorated figure lacking hands and feet. Lightly pecked intaglio. This type of composite figure is typical of Indonesian and New Guinea art.

306. Intaglio of man with knobbed head-dress and large feet and genitals, carrying a boomerang in each hand. The limbs are slender, and the posture is animated.


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Figs. 241-292

307. Intaglio of man with large ears, well-defined hands and feet with five fingers and toes, and large penis.

308. Slender man with small head, curved arms, and very long legs, lacking hands and feet, beside an indeterminate animal. Lightly pecked intaglios.

309. Head-dresses of the pendant type worn in 25, 55-6, 58. There is a small man holding and wearing pendants on bands at the top, and a large head-dress below him.

310. Over 30 little stickmen, a large number of whom are in a group at one end of, and others intermixed with, a set of eight parallel lines. One large human figure is engraved in a pecked technique over the design and may or may not belong to it. This is an old group on a cracked rock surface, and probably depicts a ceremony.

311. See 277 for explanation.

312 (see also 41-54). Two men spearing another man with barbed spears. A little man at the top or end of a bag-like figure, and three outline human tracks, are also shown.

313. Little man, with broad body and knobbed head-dress.

314. Four little stickmen, each with a rayed head-dress, carrying a boomerang in each hand. One has two boomerangs in one hand and one in the other. There is a plain spear beside the group. See also 63-70, 276.

315. Spear combat between a short and a tall man, both of whom have slender limbs and bodies, a rayed head-dress and long penis. Another small man of similar type is shown below the tall man. The latter has been speared in the duel. An old engraving on a cracked rock surface. Petri and Schulz (1951, fig. 10) thought these men to be half-human and half-plant beings because their head-dresses resemble plants.

316. Several dozen little stickmen, armed with plain-headed spears, engraved on the top and front of a boulder. Other figures in this old composition are too weathered to identify. Beside and over some of the above stickmen have been pecked full intaglios of a human foot (top left), a pair of large boomerangs, and another series of little round-bodied men armed with boomerangs. These are all well preserved.

317. Intaglio composition of the hind and fore foot tracks of a rock wallaby (left), a line of crescentic, oval and triangulate shaped figures (middle) and a conical figure with a set of bird tracks (right).

318. Intaglio of Great-billed Heron or Sea Curlew.

319. An unusual intaglio of a bird lying on its back. The long wing and leg on one side contrast with the short wing and leg on the other side.

320. Intaglio of a pair of Sea Curlews feeding, and below them a bird with a bulkier body which is probably an emu.

321. The larger figure, with its well marked hands and feet, dog-like head and long knobbed penis, is a puppy-like figure and may be a young dingo. The other figure is puzzling; looked at from one end it is a stickman with knobbed feet and penis, and from the other end a stickman holding two spheres in his hands, between which is a rounded head on a thread-like neck.

322. Intaglios of a hunter spearing a wallaby or kangaroo, the man and the animal being linked by the spear. This intaglio is pecked over an old set of little men armed with spears.

323. One of a line of five pits, up to 8 ft. wide, just above high-water mark on the southern shore of the island. The sides of two other pits may be seen at the top and bottom of the photograph. The boulders were taken out by the Aborigines to a depth of from 2 ft. to 4 ft. Cockle shells from the tidal flats adjoining the mainland are scattered about the bottom of this pit. Many engravings of turtles in various styles, and of little men, occur at this spot, which is near a gully not far from South-west Point. Further eastward are several more of these pits with sandy bottoms, and others occur on Anchor Hill. It is probable that they are totem centres.

324. Hunting composition of a little man spearing a big Mangrove Crab, with two other unarmed men, one of whom is wearing a rayed head-dress, in the picture. Also on this rock are engraved one set of 20 and one set of four eggs.

325. Two deeply-grooved men, one of whom has a large hand, with a third and smaller figure, probably human.

326. Little man carrying a large sphere, probably a turtle's egg. It may also be interpreted as a lizard eating the contents of an egg. Two human feet are engraved on the same rock.

327. A speared kangaroo, and an emu in an alert pose. Both life-sized intaglios. (Wickham, 1842, figs. 67 and 87.)

328. An intaglio composition of seven fish-like figures beside a large indeterminate oval object.

329. Two dozen or so little men—of both slim and round-bodied types, two of whom are wearing head-dresses—arranged around a large sphere, probably the gigantic egg of a turtle, like that on the head of the little man in 326. Lightly pecked intaglio.

330. Intaglio snake 5 ft. long (and bird track, lower left) engraved over an indeterminate line figure. Weathered figures on a rock beside one of three large pits 6 ft. wide and 4 ft. deep, made by the Aborigines on Anchor Hill, and similar to 323.

331. Set of five figures which include a stingray's liver. Three figures, one of which has two sets of arms and a rayed head-dress, look like gecko lizards at first sight, but are probably human beings with large genitals. They are similar to 4, 8, 34, 55-6 and 58.

332. At the top is a large bird holding a long oval object in its beak, and with a large knobbed penis. Below it are a snake about 5 ft. long and five little stickmen in either a hunting or ritual composition. Weathered intaglios.

333. Lizard, fashioned with a marked gashing technique.

334. Two large fish.

335. Lightly pecked boomerang, with an oval area of scattered peckings below it.

336. A neatly-shaped intaglio of a large fish pecked over an old and weathered composition of a dozen or more little spearmen standing in a semi-circle around a slightly larger man, who appears to be transfixed with their spears.

337. Roughly pecked intaglio of a lizard.

338. View of a hillock on the south-west coast, a site rich with engravings, found by Mr. A. Day. Those shown include a grid design, pubic apron, emu and human foot, snake, boomerang, emu and hollow-bodied man, little men both singly and in linked series of five and seven, and others.

339. Another richly-engraved site on the south-west coast, found by Mr. A. Day. The figures include the Great-billed Heron, man carrying pronged oval object, little men with large round heads, little man with bulbous penis, little woman with large circle and dot for genital organ, little people in sexual intercourse and a lightly pecked and faded boomerang, all on the left and middle rock surfaces; on the rock face on the right are two large, lightly pecked and faded emus, beside which are several little men and their tracks; over this hunting composition is engraved a graceful stick figure of a man wearing a herring-bone type head-dress and carrying two hooked boomerangs in each hand, with a further pair of them projecting upwards from his waist. In the lower left is a rock bearing the series of big-headed men shown in 279.

340. The main set of intaglio figures on this rock comprises a remarkable trio of two men with well-defined feet and penis, and wearing herring-bone type head-dresses, holding on their joined hands a third and smaller human figure with a big round head fringed on both sides and bearing a head-dress. He has a boomerang in his left hand. There are various other little human figures on this rock, and the group on the right includes men armed with spears and boomerangs hunting a small mammal.

341. A large barred outline turtle, with lightly pecked head and flippers, engraved on a rock surface that has cracked since the engraving was done. Elaborate intaglio figures of a woman and two men are engraved over the turtle.

342. Intaglio of a Mangrove Crab.

343. Intaglio set of a goanna, with well-defined long toes on its feet, hunted by three little men, one of whom has a big curved and bladed club. This composition is engraved over the tail of a large outline fish and a lightly pecked oval. The author has recorded similar intaglios of goannas at Port Hedland.

344. Intaglio snake coiled around a rock.

345. Emu and Rock Wallaby intaglios pecked over a pubic apron. [I did not locate Wickham's figs. 6, beetle; 61, native dog; 71, bird of prey seizing a kangaroo rat; and 32, shark with pilot fish.] Fig. 346. Wallaby and fish, excellent examples of the fully pecked intaglios.

Sizes

Time did not permit of measuring the many figures recorded. The human figures vary from stickmen 6 in. long to larger figures over 4 ft. long. The mammals, birds, fish and lizards range from tiny figures to almost life-size ones, and many of them approximate the latter. There are no gigantic anthropomorphs or animals depicted, the whales, for example, being no more than 5 ft. to 6 ft. long. Some of the stingrays' livers and pecked boomerangs are larger than life-size. The shiny disk shown in some of the photographs is a camera lens cover 1½ in. in diameter.

DISCUSSION

Anthropomorphs

There is a highly imaginative approach to the depiction of the human figure, many of which show considerable movement and animation, heightened by the specially selected rock faces in which they are engraved. The pair of big outline men (5) are a good example.

Although fingers and toes are not usually shown, well-defined hands and feet with from three to six digits are not unusual. On the intaglio human tracks, however, up to 11 toes are included. No attempt was made by the artists to indicate the eyes, nose and mouth by deeper grooving than the rest of the intaglio, as was done in inland sites. The majority of the figures are facing the viewer; a side view is seen occasionally, but no seated figures were observed. In general, the bodies of the anthropomorphs are rather straight-sided and omit the protuberant features of the human figure. It is the posture, or the shape suggested by the pose, that the artist has concentrated on in most of the portrayals, among which a straight up-and-down figure with arms and legs at a similar angle is perhaps the commonest type. Most of them are naked, but some are wearing a pubic apron. Man is portrayed in an extraordinary variety of forms and activities, among which fighting, hunting and ritual dominate the subjects. The varieties are as follow:—

(1) Stickmen, stiff and unimaginative, not as gracefully drawn and posed as in paintings of the Kimberleys and western Arnhem Land. No women are included. The arms and legs are either at the same angle, or the arms are horizontal. They are engraved in haphazard sets, in linked series, in hunting, fighting, dancing and ceremonial groups. (43, 47, 53, 67, 99, 104, 107, 118, 275-7, 279, 310, 314, 332, 339.)

(2) A thicker human figure, often short in stature, in a variety of action postures, frequently armed with a shield, boomerang or spear (7, 14-8, 21-2, 27, 36-7, 41, 44-6, 50-4, 63-5, 72-4, 76, 78, 80, 82, 208-9, 224, 278, 280, 312, 326, 329, 336.)

(3) A tall neckless figure, with a look of power and strength in the shoulders (6).

(4) Hollow-bodied, with big penis (35), a rare type.

(5) Elongate, with long arms and fingers, short legs, big testicles and long thin penis (9, 28, 285).

(6) A thick and often curved-bodied type, with short limbs, fine long lines for the hair, thick bag-like genital organ (8, 82) or pubic apron. In one of these figures (4) the hand is in the shape of the radiate head ornament in (2) and of the hands and feet of a spirit figure predominant in the Port Hedland engravings (48, 31-2, 34, 55, 58, 88).

(7) A rare type with a triangulate head, and head and shoulders merged to eliminate the neck (118).

(8) Little stick and a few thicker-bodied men with big round heads (71, 273).

Several features of the human figures merit comment. The hair is shown in long fine lines (4, 33), and many of them carry weapons. The head ornaments include pendant (25, 55-6, 58, 78), radiate (2, 26) and knobbed types (34). The " corroboree " posture is not uncommon, and there are many unique and unorthodox forms like 10-1, 19, 38, 49, 290 and 323.

One of the features of the anthropomorphs is the depiction of static pairs of men of which one is usually bigger than the other (5-6, 21-4, 31, 34). These pairs probably represent the two brothers characteristic of north-western Australian mythology (Piddington, 1932, 47-51; Davidson, 1949, 93; Worms, 1954, 1083), but the Ngaluma myth about them has not been recorded. They are known as Mungan by the Ngarla and as Bagadjimbiri (the place where they originated on Anna Plains) by the Njangamada. They travelled widely, altering the landscape here and there, creating springs and totem centres, instituting initiation ceremonies with circumcision by a stone knife, singing songs about the animals, places and other things they saw, and finally going up into the sky after death. The interlocking key design belonged to their bullroarers. The Ngaluma and Kariera were uncircumcised because the brothers found their skin too hard to cut. It is more than probable that these pairs represent the mythical brothers rather than the large man and small wife motif found among the paintings on Groote Eylandt (McCarthy, 1960) and engravings at Port Hedland, and exemplified by the Lightning brothers and wife at Delamere, Northern Territory (Davidson, 1936).

The not uncommon depiction of sexual intercourse, and of large genitals on both sexes, indicates that the theme of intercourse was highly ritualized, with an accent upon reproduction and fertility, a matter further discussed below. Petri and Schulz (1951) thought that some of these figures represented the reproduction of insects, or hermaphrodite-like legendary sea creatures with human qualities. This is a different style of art to that of the inland sites, of which Worms (1954, 1801-3) has pointed out that the exaggerated genitals, and the importance of sexual intercourse as a motif, are expressions of the Gurangara, the culminating rite of the

Kunapipi ceremony which spread westward and northward from the Great Sandy Desert. These coitus engravings are the latest series at Gallery Hill, Wamerana and other sites, where they represent the most westerly penetration of this cult, which is connected with Mangula and her male consort Djanba. Worms is convinced that this Kunapipi cult did not reach the coast at Port Hedland, where coitus engravings do not occur among the human figures. Those on Depuch Island, however, are thus either connected with the Gurangara cult or represent a different mythology in which coitus was emphasized.

Fighting is an important subject in this art (41-54, 63-70, 313-4, 336). Most of these compositions appear to represent spear ordeals in expiation of a crime, or for men absent when a relative died and who were not allowed to speak until they underwent this rite (Harper, 1886, 289). There are not enough men participating in them to represent battles between groups. It is noticeable that both spears and boomerangs were used by the stickmen and other warriors, but that the boomerang is usually the weapon figured in the pecked-intaglio period, probably because it is such an attractive motif.

The big-headed men form an important subject on this island, and 71 and 273 are excellent examples of them. The key to their interpretation lies in 326 and 329, where a large sphere, with an unpecked area representing a hole or nucleus left in the middle, is shown being carried or surrounded by little men. I believe this sphere to be the egg of a turtle, greatly magnified in size in relation to man, because of its economic and ritual importance, and because in most of the hunting compositions the principle of tiny men hunting large animals is followed. It is also of interest to note that some of the turtles are shown with eggs inside their bodies, as in 226-9. This interpretation may explain the meaning of the group in 273 as a series of turtle-egg-headed men, some of whom are carrying turtles. The sphere could represent the egg of a bird or lizard. Mr. Day has informed me that he has seen, in the north-west division of Western Australia, a ring of little men engraved around a huge round boulder which probably represents the egg of an emu or turkey on the mainland.

Hunting Compositions

These are of great variety, and are more abundant in this island's art than in any other known engraving site in Australia, excepting the outline engravings of the Sydney-Hawkesbury district, eastern New South Wales. They include the hunting of turtles, bandicoots, rock wallabies, kangaroos, mangrove crabs, dolphins, goannas, snakes, emus, a variety of birds which inhabit the tidal flats, various species of fish and some indeterminate animals.

The weapons used are the spear and the boomerang. Apart from depicting the hunter and animal technical devices employed, which are typical of Aboriginal art generally, include: the linking of the hunter and animal by the weapon (99, 322, 324); portraying the animal with its and the hunter's tracks (103); showing the hunter's and animal's tracks only (100-1); little stickmen or thicker-bodied men hunting very big animals (99, 117, 322, 324, 327, 332); engraving the animal's tracks beside a spear or boomerang (106, 122, 114). Animals preying on one another are shown in a dingo killing a curlew (94) and a bird catching a fish (93), and various sets of animals are commonly shown beside one another (119, 317, 331).

These intaglio hunting compositions resemble very closely those among the outline engravings of the Sydney-Hawkesbury district, especially 322 and 327 (McCarthy, 1944-59). In the latter area the hunter and animal are usually natural size, but where the animal is of gigantic proportions the ratio of small hunter and large animal operates in both areas.

Zoomorphs

Mammals

These are comparatively few in number and are limited to the mainland kangaroo (126-7, 327), dingo (94), possum (130), jumping mouse (129, 300), one of which has a tail tassel, and the island rock wallaby (122, 128, 133, 301, 322, 345). Several mammal figures are indeterminate. Three fingers and toes are sometimes shown, but usually there are none. Apart from the hunting compositions, engravings of mammals are not as numerous as are those of birds and fish. Most of them are posed in a standing posture, but the possum (130) and the two mammals (132, 300) are alert action studies.

Birds

Apart from the emu (138, 146-7, 327, 348) of the mainland, all of the birds engraved are wading species which inhabit the tidal flats extending from the mainland shore. Most of them are posed bending forward, often with beaks open as they do when feeding, are plump-bodied, and possess three-toed feet. The emus are shown feeding (147) and standing on the alert (327), and they form a comparatively uncommon subject here. On a number of engravings the body is shown on one face of a rock while the neck stretches round at right angles to another face on which the head is engraved.

Fish and Marine Mammals

The seas of this region abound in fishes. Netting and spearing in the shallow waters were the principal methods of catching them, as hooks were not used. Several unusual figures of sawfish (165, 188-9) were found. The stingray is abundant on the tidal flats but is a rare subject among the engravings, only one small intaglio and two outlines of them being recorded. Engravings of sperm whales are probably due to their being stranded in shallow waters on the tidal flats (as there is a 25 ft. drop of tide in this region), thus providing a feast for the Aborigines. Dolphins are also a rare subject.

Turtles are among the commonest subjects on the island. From one to six or more may be seen engraved on adjacent rocks, most of them portrayed in a swimming posture, and the variety of styles is noteworthy. They could have been speared from the rocks of the island, on the tidal flats and among the mangroves at high tide, while the animals and their eggs were collected on the sandy beaches.

Reptiles

The series of snake figures recorded probably represent the " boa " or python seen by the French expedition on the island. They are shown coiled (201) or lying (198, 330) on a rock, in pairs (200) as though mating, being hunted (162-3, 199, 202, 332), and catching a rock wallaby (197). In the Bagadjimbiri myth of the northern Njangamada (Piddington, 1932, 48) the brothers turned into a big water-snake called Bulaing when they died. This snake is not the rainbow serpent, but controls the wet and dry seasons, and stands to the women in the same way as Bagadjimbiri does to the men. Bulaing is probably a reflection of the Kimberley Wandjina-Ungud belief and has no bearing on the Depuch Island snake engravings. Petri and Schulz (1951) thought there were no snake engravings on the island.

The lizards include the goanna (157, 160, 164), skink (333), gecko (331) and other species not indetifiable. They are shown in static postures, and one pair (158) is engaged in sexual intercourse.

The young frog (161) is an unusual subject. Frogs occur on bark paintings in Arnhem Land and Groote Eylandt, where they are associated with rain (Mountford, 1958, 358).

Invertebrates

These comprise a few insect-like engravings (252, 255, 258, 269, 284, 287) and some bag-like figures (194-6) which are probably of marine origin and may be bêche-de-mer or a similar creature. The outstanding subject in this group is the Mangrove Crab, of which three splendid figures (193, 342) were found and in which the legs vary from 8 to 10 in addition to the swimming pads. In 324 little men are spearing another large crab with 10 legs. There are no mangroves on the island, but the foreshore of the mainland is a jungle of them. The Australian Museum possesses a bark painting of this crab from Groote Eylandt, and the author has recorded it among the rock engravings at Port Hedland.

Material Culture

The Ngaluma and neighbouring tribes used (Harper, 1886; Richardson, 1886; Withnell, 1901; Clement, 1904) spears with plain heads and with long rows (single and double) of barbs, and sometimes reversed barbs; rounded throwing sticks; boomerangs; spearthrowers and shields. All of these weapons are shown either singly or in use among the engravings. Only one shield bearing the parallel zigzag design (253) was seen, but no decorated sacred boards or spearthrowers were found. A hooked boomerang is shown in 343, and another occurs on Anchor Hill; these were made in the Northern Territory and reached the Ngaluma through barter and exchange along traditional routes (McCarthy, 1939, 81-2, map 10). Their engravings are in the furthest locality westward yet recorded. Petri and Schulz (1951) said weapons are a comparatively rare motif on Depuch Island, and thought that the pecked boomerangs represented the rainbow.

Objects such as the twined spinifex fibre basket and nets, hafted stone adze, fish net, swimming log, fluted wooden scoop, bailer and conch shells are not shown among the engravings.

The fringed apron (233 and others) is the commonest subject among the ornaments and clothing; it varies from short to long, with short to long fringe, and has up to 16 strands. Richardson (1886, 296-7) said the Ngaluma wore an apron of green leaves suspended from a hair girdle, but the one shown in the engravings appears to be a string type. It was identified by Petri and Schulz (1951) as a comb which is unknown to the Ngaluma. The rayed feather head ornament, with triangular base, is depicted, and it is interesting to note that the hands and feet of a human (4) and dog-like (321) figures on Depuch Island, and of a spirit being predominant at Port Hedland, are similar in shape to this ornament.

The pendants on the head ornaments in 25 and 56 may be spinifex-rats' tail tassels hung from the head-band, and the knobs on the hair in 33 and 34 are probably pellets of gum, both of which were worn by the local tribes (Harper, 1886, 288; Brown, 1913, 169). Radiating stiff lines capped with a knob form the head-dress of a Mimi and of another human figure, and several long strands ending in knobs form an ornament on a Nalbidji woman in the cave paintings of western Arnhem Land (Mountford, 1956, figs. 31, 49A, and pl. 50).

Other ornaments which the people wore, but which are not shown among the engravings, include armlets, forehead band, pearl shells suspended from the waist girdle, large bullroarers attached to the waist girdle and small bullroarer worn in the back of the head-band, shaved sticks, bunches of emu feathers in armlets and hung from the back of the waist girdle.

Head-dresses of the type worn in totemic increase and other ceremonies are shown in 2, 25, 58, 235 and 309, but no descriptions of these ceremonies exist.

Generally speaking, material culture is not a common motif, as Petri and Schulz (1951) commented.

Designs

Linear designs are comparatively rare among these engravings, and are not very complex in comparison with those at Port Hedland. They are best represented by 261, 264, 273-274 and 291. Petri and Schulz (1951) regarded the comb (sic pubic apron), spherical structures, lines, crosses, etc., as symbolic representations or ornaments from cult objects with an esoteric meaning.

Techniques

Of the six techniques previously defined (McCarthy, 1958, 14) the scratched outlines in 26 and 29, punctured outline in 325, punctured intaglio band in 315, and fully punctured intaglio in 307, are present on Depuch Island. Abrading was also recorded on the flippers and tail of a turtle (92, 210), and on the whole body of another turtle on Anchor Hill. The intaglios embrace three techniques in which the whole surface is not removed, including lightly pecked (305, 326), crudely pecked or battered (337) and gashed (333), and also the full intaglio in which the surface is completely pecked, either with or without a defined or grooved outline.

Wickham (1842) and Stokes (1846) surmised that the artist first drew the outlines and then chiselled them out with pointed stones, while the working of the whole surface was secondary. Withnell (1901, 29) said of the Ngaluma that " they have very many rock carvings; every hill that has suitably hard stone will have some kind of a figure tattooed thereon. They do not choose the softer rocks and mainly prefer the basalt and granite. The method adopted is to draw the outline with chalk or ochre and with a sharp hard stone hammer within the outline until the rock is pitted away about one-eighth of an inch deep . . . The carvings are mainly representations of men, kangaroos, rats, opossums, emus, turkeys, fishes, spears, shields, native weapons of all kinds, and many men and women in a variety of vulgar attitudes." Clement (1904, 9) said that between the De Grey and Fortescue Rivers, south of Roebourne, " very rudimentary carvings occur on almost all hill tops of emus, kangaroos, turtles and human beings; they were drawn in chalk and were then repeatedly hammered along the lines." There is nothing in either Withnell's nor Clement's statements to prove that they actually saw the natives engaged in rock engraving, and they are, like Wickham's, simply surmises of how the engravings were made. Clement no doubt had access to Withnell's pamphlet. Regrettably, we can throw no further light on the techniques today.

Several different kinds of percussive implements were probably used on Depuch Island. One was a cornered hammerstone that produced a pit, another a rounded or flat faced hammerstone that produced a battered surface. These could both be made from the island stone. A third implement with a relatively sharp edge that produced a gash or cut might have been the hafted stone adze (Richardson, 1886, 297). This technique is shown in straight parallel lines in 91; in others (333) the gashes have been made one upon the other to a depth of one-eighth of an inch or more.

For the abrading in the turtles (210), a muller or piece of the island stone would suffice.

The depth of the engravings varies considerably. Some of the deeply grooved outlines are $\frac{1}{4}$ in. deep, but other outlines, like the design in 273, are less than $\frac{1}{16}$ in. The same applies to the intaglios. Those on the vertical rock faces are mostly shallow, from $\frac{1}{16}$ in. to $\frac{1}{8}$ in. deep, and reveal the greenish-blue of the rock, due to the fact that the prisms and masses of rock are continually breaking up and their surfaces are not weathered to as great a depth as are those of the reddish-coloured boulders which broke away a very long time ago. Along the foreshore

the wash of the sea has rolled and smoothed rocks bearing engravings, and many of these are barely discernible. On Anchor Hill and in Watering Valley and similar localities many of the engravings are deeply grooved or pecked for up to $\frac{3}{16}$ in. and $\frac{1}{4}$ in. into the reddish-buff patinated surface of the boulders.

Styles

Twelve of the styles among the engravings on Depuch Island fall into the same categories as cave paintings in Australia (McCarthy, 1958, 33-4), and the following were recorded for this island:

1. Dotted outline (50).
2. Outline (50, 127, 170).
3. Outline with barred interior design (11).
4. Outline with striped interior design (79).
5. Outline with striped broken line exterior design (91).
6. Outline with gridded broken line (206, 217-8, 224).
7. Outline with interior broken line (other than barred, striped or gridded) (222-3, 253, 264, 273).
8. Outline with dotted interior (185, 206, 225-9, 268, 301, 339).
9. Outline with solid punctured limbs, flippers, fins, head and tail (127, 213, 215, 221).
10. Outline with solid punctured limbs, flippers, fins, head and tail and lightly pecked (336) interior.
11. Outline with solid abraded head, limbs, fins, flippers and tail (210).
12. Outline with solid abraded interior (over pecking).
13. Linear (120, 233, 261, 281-2).
14. Stickmen (29, 310).
15. Geometric (236-7, 266, 270-2, 291).
16. Banded intaglios (108, 166, 169, 180, 188, 208, 220, 222, 263, 274).
17. Intaglio with (*a*) stippled (335), (*b*) lightly pecked (306, 308), (*c*) crudely battered (337), and (*d*) neatly pecked surface (336).
18. Intaglio and line design combined (153).

The above fall into three main groups of outline, linear and intaglio. They were not all employed during the one period, some being limited to the earlier outline and others to the later intaglio periods of engraving.

It is thus possible to claim that there is a similar heritage of styles in both rock engraving and painting in northern Australia, as a comparison with my study (1955, 1960) of the paintings on Groote and Chasm Islands will demonstrate. The paintings, however, appear to have been favoured in the vast region extending from the Kimberleys through Arnhem Land to Cape York, and engraving west of the Kimberleys in north-west Australia. The styles, too, in the two techniques have a different order of succession, because whereas in the paintings, silhouettes and outlines go back to the earliest times on Groote and Chasm Islands, in engravings the succession has been from the outline to the intaglio or silhouette in many parts of Australia. There is, however, a blending in the adoption of interior line designs in both arts, and it is in this field that correlations may be found.

Superimpositions and Antiquity

Time did not allow of a sufficiently detailed study of superimpositions* on Depuch Island, but those that were noted support data from Port Hedland and western New South Wales sites. They are as follow: Intaglio turtle or fish over outline man (13); intaglio human figures over outline turtle with grid design (92, 341); indeterminate intaglios over stickmen group (277, 311); intaglio fish over stickmen group (336); intaglio hunting composition of goanna, hooked boomerang and men over tail of large outline fish (343); intaglio emu and rock wallaby over linear pubic apron (345); intaglio men over dotted (with spaced punctures) outline oval (50); intaglio emu track over stickmen; intaglio fish over linear design (285); intaglio boomerang over stickmen; vertical pair of intaglio boomerangs over banded outline oval; intaglio mammal and man over stickmen and linear design; intaglio turtle over linear pubic apron; stickman

* To be dealt with in a forthcoming paper, with Professor N. W. G. Macintosh, on Mootwingee in western New South Wales, and in a later paper on Port Hedland.

over outline turtle and boomerang (62); outline fish with partially stippled interior over fully-pecked intaglio of indeterminate figure (185); stippled intaglio bag-like figure over fully pecked intaglio (194); unweathered spiral over faded outline turtle with gridded interior (206); elaborate linear man with hook boomerangs over intaglio emu (339).

The above series of superimpositions indicate that (1) group 1, the naturalistic outlines, with or without interior designs and the stickmen, are consistently overlaid by group 3, pecked intaglios; (2) that group 1 is also overlaid by group 2, which includes the spiral, and these by group 3 and other linear or geometric motifs; (3) that in group 3 the fully-pecked intaglios tend to be overlaid by the stippled and battered intaglios. There are thus three periods of engraving on the island, and there are several sub-periods in the latest pecked intaglio period.

The abraded figures probably belong to the intaglio period, but the chronological status of the incised figures is uncertain.

The antiquity of rock engraving on Depuch Island thus covers a considerable period of time, probably several thousands of years. Most of the figures in the first or Outline naturalistic period are in a faded condition, as are, however, many of the later intaglios. On the other hand, many of the figures in the second or Design period, and a large number of the intaglios, are perfectly preserved, as are engraved dates of 1840 (H.M.S. Beagle), 1907 and 1914, which are completely unweathered. State of preservation is not a reliable guide to the age of the engravings. Davidson was of the opinion (1952, 101) that we will never be able to determine the historic age of the north-west Australian engravings, as chronologically we have nowhere to start from. Detailed study of superimpositions in this region, however, will throw a great deal of light on this problem.

Although the stickmen belong to an early period of engraving, their use continued into the Pecked Intaglio period, where they are featured in hunting compositions. It is further probable that the depiction of some of the figures in the Design period, particularly the pubic apron, was continued into the Intaglio period because in some instances a pubic apron is engraved beside an intaglio man and both appear to be in the same perfect state of preservation. The intaglios probably continued to be made until the coming of the white man, and they constitute the majority of the engravings on the island.

The above superimpositions suggest the following comparisons with the cave paintings of western Arnhem Land: (1) The outline naturalistic engravings may be correlated with the outline and silhouette paintings in the earliest period; (2) the stickmen may be correlated with the Mimi paintings; (3) the Design period is not represented among the paintings; (4) pecked intaglios may be correlated with the X-ray period.

Petri and Schulz (1951) were of the opinion that the symbolic geometrical drawings could not be interpreted, and possibly belonged to the totem legends of the old Pilbarra tribes, with whom we have never been familiar.

The same order of superimpositions occurs at Port Hedland, where stickmen are not represented, but where motifs of the Outline and Design periods are richly represented, and where immense numbers of tracks of humans, emus and kangaroos predominate among the very small number of pecked humans and animals in the Intaglio period.

The inland galleries described by Worms (1954) appear to include an early Outline period, followed by a scanty Design period, both overwhelmingly dominated by the pecked and stippled intaglios and by the most recent Gurangara style of graceful and decorative human figures. The succession is similar to that on Depuch Island, excepting for the Gurangara style inland, and contrasts strongly with that at Port Hedland. It is possible that Depuch Island supplanted Port Hedland as a ceremonial centre associated with rock engraving in the Intaglio period.

Subjects and Function

It is obvious from a study of the illustrations that the activities of human beings interested the Ngaluma artists who visited the island. In the early Outline period stickmen are shown engaged in many hunting, fighting and ritual activities. In the later Intaglio period hunting and sexual activities become important, and though many men are armed with boomerangs and shields they are not actually fighting. It almost seems as if the period of the stickmen was one of unrest and hostility, as with the Mimi in western Arnhem Land, but that of the Intaglio was one of peace, in which ritual activities flourished.

Floral motifs are lacking.

The illustrations demonstrate the limited range of motifs in both the Outline and Design periods, and in the latter the great array of linear designs at Port Hedland is lacking. The scarcity of animals in the Outline period contrasts with their importance in the Intaglio period. Material culture is unimportant in all periods. This emphasis on naturalism in the Intaglio

period on Depuch Island and at Port Hedland and inland sites is striking. As part of it, anthropomorphs are common on Depuch Island, and among them appear the mythical brothers of the north-western Australian mythologies, men in ritual attire, people engaged in sexual intercourse and birth, with their genitals exposed in exaggerated size.

What is known of the religion of the Ngaluma reveals the nature of the ritual background of their rock art. According to Withnell (1901, 1-4) the Ngaluma and neighbouring tribes believed in a common creator spirit-being named Ghurker, whose wife gave birth to the first couple sent to populate the earth. Another spirit called Mulgarra lived both in heaven (defined as a space) and on earth, and they had a strong belief in the spirit world for both good and evil. There was, too, an evil spirit called Juno (Richardson, 1886, 293). Ghurker created the Tarlow sites and the increase rites. Each living thing is a totem which had a Tarlow, a stone or pile of stones, which were hammered with round stones or clubs in the increase ceremonies. The women participated in these ceremonies, and there was no prohibition on eating one's totem (Withnell, 1901, 5-6). Radcliffe-Brown (1913, 60, 167) ascertained that each of the patrilineal local groups formed a totemic clan with up to 18 or more totems, for each of which there was a *talu* centre of stones. The head of the clan took the leading part in the rites, during which the names of different parts of the local group's country were called and songs recounted how the *talu* sites were created. I did not see any heaps of stones on Depuch Island, and am of opinion that the pits (323), and some of the prominent stones on which figures are engraved, served as the *talu* sites. The Garadjeri use pits or depressions in the ground which are cleaned out and the stones thrown in different directions for the purpose (Piddington, 1932, 373-400). Clement (1901, 6-7) said that the various movements and activities of the totem animal were imitated and all of the weapons and utensils used to kill and prepare it as food were included in the increase rites at the *talu* site, which was usually a heap and not a single stone. One of the most important ceremonies conducted on the island concerns a huge egg-like object, which was carried on the head and which subsequently became the head (71, 273, 326) or is encircled by little men (326), and a pronged object also carried on the head (273). Various spirit figures, some of which are composite human and animal creatures, cannot be interpreted.

The intaglio art as a whole is the product of a typical Australian Aboriginal religion and mythology in which the themes of ancestral and other spirits, reproduction and the animals the men hunt and ritualize, feature prominently. Petri and Schulz (1951) concluded that these rock engravings are a notable expression of the totemic view of the natives' world, as are the Wandjina of the Kimberleys, although no direct proof exists of their use in ritual increasement. Some of the engraved figures could represent animals prohibited to a young man, like small kangaroos and emus (Brown, 1913, 176), as part of his education through ritual. As no record of the Ngaluma mythology exists, the problem of the interpretation of their rock art cannot be taken any further.

Artistic Merit

Technically, the depiction of the figures on Depuch Island compares closely with that elsewhere in Australian rock art. The imaginative approach of the Ngaluma to the subjects is found also in the Kimberleys and western Arnhem Land paintings, and to an even greater extent in the Gallery Hill and Wamerana type of rock engravings. But on this island the occasional use of the shape of the rock (297, 344) to show the form of the body, the innumerable compositions of a ritual, hunting, fighting and sexual nature, the great variety of human and spirit figures and the many excellent figures of animals, warrant its being denoted as one of the most artistically interesting sites of naturalistic engravings in Australia.

The artists often selected the boulder faces carefully to suit their subject, both in shape and position, and they probably placed some of the rocks in position to work upon. Many of the engraved rocks in Watering Valley, which are held in place by boulders around them, have been in their present position almost since the inception of engraving on the island, because engravings on them are in all states of preservation and some of them are very faint. Thus, there is not very much movement of the rocky sides of the ridges.

Davidson's (1952) data indicates that engravings typical of the Intaglio period are found mainly in the north-western division of Western Australia, and probably in the Canning division, while those of the Outline and Design periods extend further south into the Murchison division and possibly beyond. Stokoe (1959) described engravings of the Design and Intaglio periods at Yarlarweelor in the northern Murchison division. An undescribed site has been reported in the Kimberleys, about 30 miles from the mouth of the Drysdale River. The concentric circles (271-2), double circle (270) and set of inverted U's (245) are characteristic of the living art of central Australia, but they are rare on Depuch Island. Together with the *kurdaitja* shoes (267-8) and hooked boomerang (2), they illustrate the traits introduced into the local culture by the traditional " trade " from the central Australian region through the Great Sandy Desert tribes.

On Depuch Island the emphasis is on naturalism, even though reproduction as a theme is stressed in engravings of sexual intercourse of humans and of animals. In the inland sites animals are extremely rare—Worms (1951, 1077) counted 11 animals as against 74 human figures on Gallery Hill—and the main emphasis is on the ritual human coitus of the Gurangara cult. The head-dresses of the two sites differ considerably. Those worn by the men in the Depuch Island art include radiate and pendant types (with knobs and other attachments), but those in inland sites (Worms, 1951, fig. 4) include looped, barred, simple and double branched, and double wing forms unknown on Depuch Island.

Worms (1951, 1075, pl. 4c) classified the types of human figures at Gallery Hill and Wamerana as:

(1) bulb or square form, but his type is an echidna with a thick pecked band outline and stippled interior, a form which I have recorded in Groote Eylandt paintings (McCarthy, 1960) and which Basedow (1914, 205, pls. VB, VIIB) called both platypus and echidna in central Australia;

(2) Drop type in outline with dotted interior, but his type is, in my opinion, a praying mantis, one of which, in full intaglio, occurs on Depuch Island;

(3) Skeleton type, a thick-banded linear form;

(4) Rounded or fleshy type, pecked or stippled without heavy outline;

(5) Match type, with double lines linked by bars.

Excluding the first two doubtful types, photographs show that the third or skeleton type and the fifth or match type are superimposed over the fourth or fleshy type in these galleries. There is only one figure (5) on Depuch similar to the fleshy type which occurs also at Mt. Edgar or Mentheena (Davidson, 1952, fig. 4), 60 miles west of Marble Bar. None of the skeleton or match types, or the echidna (square or bulbous type), are represented on the island. There is also an emphasis on intaglios of animals, particularly lizards, at Yarlarweelor (Stokoe, 1959), but not enough detailed records are available from other sites elsewhere in Western Australia for comparative purposes.

Points of difference with Davidson's review (1952, 90-1, 93, 95) of rock art in Western Australia are that (1) snakes are not, numerically, an important motif on Depuch Island; (2) emus are only fairly well represented among the birds; (3) the human figures commonly show the hair in radiate fashion, and many of them wear head-dresses; and (4) compositions are plentiful.

State of Preservation

There is a tremendous variation in the state of preservation of the various figures. Many are so faint that they can only be distinguished in a side light, and there are all gradations from this faded weathering to those that are perfectly preserved. Some of the engravings along the southern shore have a rolled appearance, as though they have been smoothed by the tides, while those on the vertical rock faces on Anchor Hill, which have a very thin patinated surface, are also weathered to a smooth-faced appearance. The best-preserved are those engraved in the thick, patinated layer on the surface of the boulders on the sides and tops of the ridges and hills. They show out well as biscuit-coloured figures against the reddish-brown of the rock, and many of these are in a perfect state of preservation, as a perusal of the plates will demonstrate.

Localities

Engravings were recorded from five localities at the southern end of the island, and many more yet to be recorded are scattered over the ridges all over the island and along the shores of the central and northern portion. A more thorough investigation of the following five sites, particularly Watering Valley, would yield more motifs. The following is a list of the localities of the engravings illustrated:—

1. Southern shore from South-west Point to Wickham Beach: Nos. 7, 14, 24, 28-9, 34, 41, 43-8, 51, 53-4, 62, 74-7, 79-80, 84-5, 87, 89-90, 93, 102, 104, 108, 112, 118, 126, 132, 134, 136, 141, 152-3, 160, 164, 167, 169, 174, 178, 192, 197, 206-10, 216-7, 219, 221-2, 224, 226, 228-9, 235, 246-8, 251, 260, 262, 266, 269, 281, 286, 291, 299, 308, 312, 321, 330, 332.

2. Anchor Hill: Nos. 8-9, 11-2, 16, 18-9, 22-3, 25, 27, 35, 57, 59-60, 67-8, 73, 82, 94-5, 99-101, 103, 105-6, 112, 114, 116-7, 119-21, 125, 130, 148-9, 154-5, 165, 168, 171, 173, 180-1, 184, 188, 193-4, 203-5, 211-4, 218, 220, 223, 230, 238, 240-1, 245, 252, 254-5, 257-8, 263, 267, 270-2, 284-5, 287-9, 302-4, 315.

3. Northern end of Beagle Beach: Nos. 237, 298, 310.

4. Watering Valley: Nos. 2-5, 10, 13, 15, 17, 20-1, 26, 42, 50, 55-6, 58, 61, 63-72, 78, 81, 83, 86, 88, 91, 97-8, 107, 109-11, 113, 115, 123-4, 127, 129, 131, 137-40, 143-5, 147, 149, 156-9, 161, 166, 170, 172, 175-7, 179, 182-3, 185-6, 190, 192, 195-6, 198, 200-1, 215, 225, 234, 236, 242-4, 249, 250-1, 253, 256, 259, 261, 264-5, 274, 277, 282, 290, 292, 297-8, 300-1, 305-7, 309, 311, 313-4, 316-20, 322, 324-6, 328-9, 331, 333-7, 340.

5. South-west coast: Nos. 6, 30-3, 36-8, 49, 52, 96, 122, 133, 142, 151, 162-3, 189, 199, 202, 227, 231, 239, 268, 273, 275, 278-80, 283, 341-5.

6. General: Nos. 40, human feet; 152, emu tracks; 191, stingray livers; 232, boomerangs; and 233, pubic aprons, include figures from several of the above localities, and each of these motifs in all of the above localities.

The figures are engraved on vertical walls (in some cases now above reach of a human being because the rocks or platforms from which they were made have broken up into boulders), on rock platforms and on loose rocks. On Anchor Hill some of the engravings on a rock platform have been obscured by birds' dung.

Grindstones.—Two slabs of stone about 2 ft. long were found that had been used as millstones. The seeds ground on them would have to be brought from the mainland.

Acknowledgments

My sincere thanks are due to the Wenner-Gren Foundation for Anthropological Research in New York, whose grant of funds made this work possible; to Mr. Adrian Day, Native Welfare Officer at Port Hedland, for the great amount of trouble to which he went to transport me to Depuch Island and for his untiring assistance in locating engravings; to Mundabullagana Station for its hospitality during my visits to the island; to Miss Janelle Bailey, technical assistant at the Australian Museum, for the long series of line drawings that she so carefully made from my photographs, and to members of the scientific staff of the Australian Museum for identifications of some of the animal engravings.

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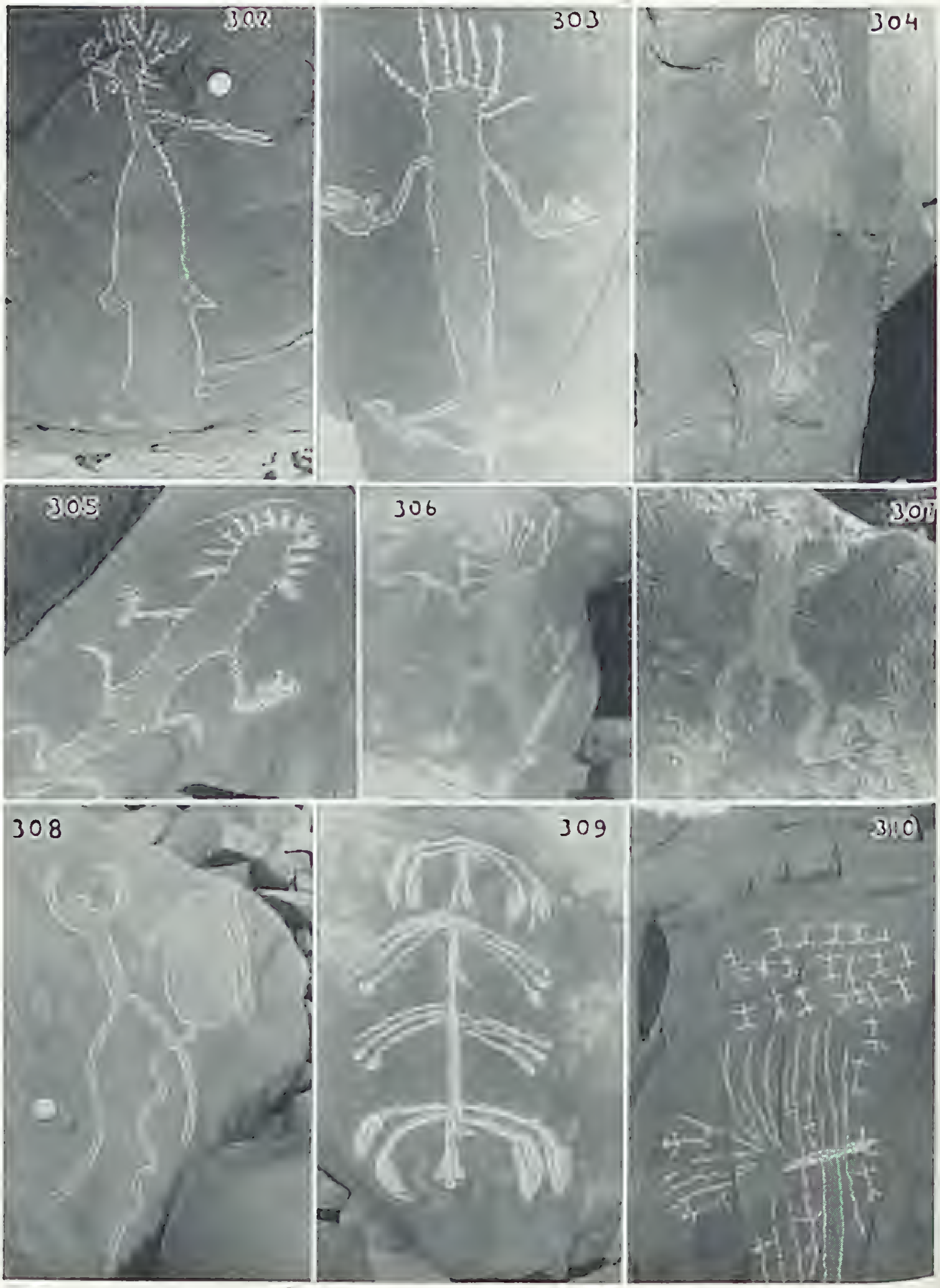
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PLATE XIII

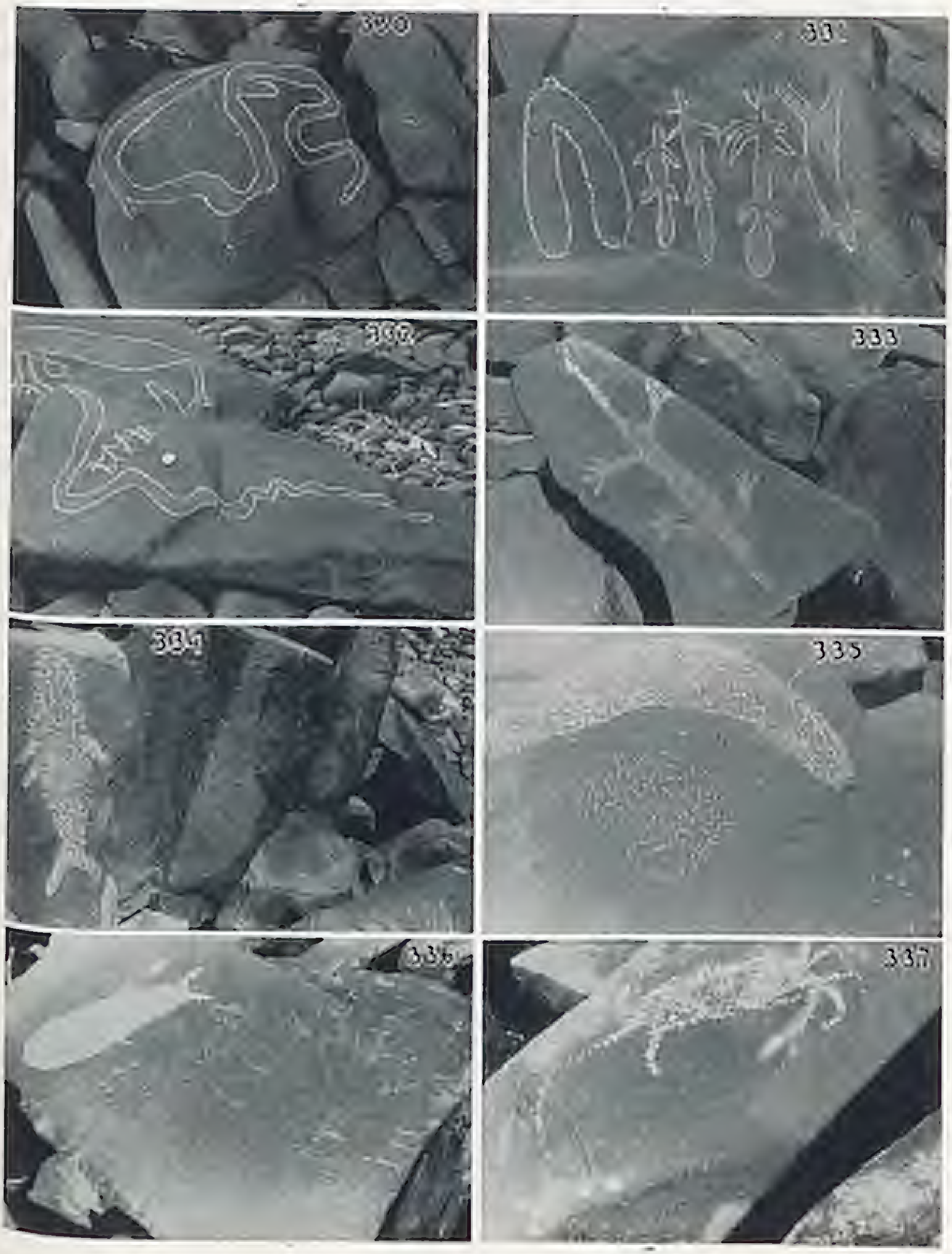


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Fig. 346

PARASITIC COPEPODA FROM AUSTRALIAN WATERS

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Figs 1-250

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CONTENTS

INTRODUCTION

Our knowledge of the parasitic Copepoda has greatly increased during the past 50 years. Except for a limited number of records from expeditions conducted mainly in the latter half of the last century, very little was known about their distribution and taxonomy outside European and North American waters. These early expeditions covered only limited areas of the Southern Hemisphere, and the only notable research on parasitic copepods published since then by local workers outside Europe and America has come from Japan, China and India. I was therefore greatly interested when, some years ago, the late Dr. Harold Thompson, at that time Chief of the Fisheries Division of the Commonwealth Scientific and Industrial Research Organisation in Australia, offered to send me material for examination. The collection I received from him contained the many new species I had expected—ones that were parasitic on the more stationary Teleosti. Other copepods in the same collection, taken from sharks and larger and more cosmopolitan fishes, were, as could be expected, of known species which had previously been found in other parts of the world. I am grateful for the courtesy shown by Dr. Thompson in arranging for this material to be collected by scientists on his staff. These collectors were Dr. A. G. Nicholls, Dr. M. Blackburn, Mr. A. M. Olsen, the late Mr. W. S. Fairbridge and Dr. A. M. Rapson. Some specimens were also sent to me by Mr. G. P. Whitley (ichthyologist, Australian Museum) from Perth, Western Australia, when he was temporarily associated with Dr. Thompson's administration. My thanks are due to all these gentlemen for their kind co-operation. Names of collectors are noted under species dealt with in the text.

When it was realised that the collection received was so unexpectedly extensive and yielded such a large number of new species, I decided that it was my duty to include in a report all the other unpublished material of parasitic Copepoda housed in Australian museums or universities. I therefore wrote to all of these institutions, requesting them to make available to me any specimens they might have, so that these could be determined and reported upon along with the material I had already received. The requests yielded a relatively good collection of copepods from the Australian Museum, Sydney, New South Wales, and one specimen from the South Australian Museum in Adelaide. I thank the Directors of these two institutions for having kindly placed their material at my disposal, and also Mr. F. A. McNeill, of the Australian Museum, for considerable editorial assistance.

I Suborder ARGULOIDA

Family Argulidae

Genus **Argulus** O. F. Müller, 1785

Argulus macropterus, sp. n.

Figs. 1-3

Locality, Host and Record of specimens: 1 female, the holotype, on *Mugil* sp. at Mandurah, near mouth of Murray River, Western Australia. Collected by the Chief Inspector of Fisheries, A. J. Fraser; no date. Australian Museum Reg. No. P11881.

Female: The carapace is elliptical, and longer than wide. The cephalic area is distinctly separated from the rest of the carapace, with the front margin projecting strongly forward. The posterior sinus is deep, extending forwards for about half the length of the carapace, and is lined by two very large lateral lobes, their posterior halves partly overlapping each other and reaching behind the abdomen, which they entirely cover. The abdomen is strongly bifurcated for nearly three-fourths of its length. The first antenna is five-jointed, with three basal joints, of which the third terminates with a hook; extending from the base of the hook is a two-jointed palp. The second antenna is also five-jointed, with the last joint shaped like a long and slender palp. The sucking discs are very large and prominent. The maxilliped is short and weakly developed, and without any terminal claws.

The colour of the female when alive was described as greenish.

Argulus japonicus Thiele

(Figures 4-7)

Argulus japonicus Thiele, 1900, p. 48.

Argulus trilineatus Wilson, 1904, p. 681, figures 34-38.

Argulus japonicus, Yamaguti, 1937, p. 781, figures 1-9. *Id.,* Meehean, 1940, p. 494, figure 32.

Locality, Host and Record of specimens: 1 female, parasitic on a Goldfish Carp (*Carassius auratus*)—freshwater aquarium fish from Sydney, New South Wales. Australian Museum Reg. No. P. 11179.

Remarks: This species is distributed throughout the world in almost every region where goldfish are found.

II Suborder CYCLOPOIDA

Family Chondracanthidae

As earlier recorded (Heegaard, 1947), this family belongs to the Cyclopoida, with which suborder its members have many things in common, particularly the structure of the mouth appendages. The only character they have in common with the Lernaeopodidae, where they were placed by Wilson in 1932, is the presence of pygmy males. The morphology, however, is very different, and there is an absence in the Chondracanthidae of the pupal stage characteristic of the Lernaeopodidae.

Pseudoblias gen. n.

Type species *P. lyrifera*, sp. n.

In 1863 Kröyer described under the name *Blias* a chondracanthid copepod he had received from the museum in Vienna. It had the same mouth appendages as *Chondracanthides* and two thoracic segments plus the large trunk, but the latter was round and without lappets. Furthermore, there were two abdominal segments instead of the normal single segment. Also, the two pairs of thoracopods were not of the normal unjointed bifurcate type found in chondracanthids but were unbranched and three-jointed—the first pair tipped with a well-shaped claw, while the second carries at the tip six to seven short and strong spines. Lastly, as far as could be seen, the two pygmy males attached to the female were of the normal chondracanthid type.

Kröyer's material of *Blias* was a single female from Brazil, and his record of the genus is the only one that has ever been published.

In the present material from Australia there are two females which closely resemble Kröyer's genus. Like *Blias*, they have two abdominal segments. The trunk is also round like that of *Blias*, and not flattened as in *Chondracanthus* and *Acanthochondria;* the two pairs of thoracopods are unbranched, not jointed, and are without claws or spines. Also, in one of the females the right first thoracopod has a small bud where the limb in chondracanthids should be branched, which indicates that the unbranched limb in this case is secondary. The small male from Australia is also of the typical chondracanthid type. Because of the marked difference in the thoracopods I do not feel justified in including the specimens before me in the genus *Blias*. However, as they possess characters strongly resembling those of *Blias*, and also inclining towards those of *Acanthochondria*, I have chosen to establish the new genus *Pseudoblias* for their accommodation.

Pseudoblias lyrifera sp. n.

(Figures 8-13)

Locality, Host and Record of specimens: 2 females and 1 male, including the holotype. found on gills of *Rhombosolea tapirina* in Swan River estuary, Western Australia, 24.9.1942. Collector, Mr. White.

Unfortunately, the rather poor condition of the badly preserved specimens is responsible for the somewhat brief description of this species. Dissection of the single male could not be attempted, but as the differentiating characters between males of the species of all chondracanthids is very small, no point of systematic importance is expected to be found.

Female: As previously noted, the female is very close to *Blias*. From a dorsal view the head is spindle-shaped, with a lyre-shaped figure formed by the muscles of the second antenna, from which the species name is taken.

The head is clearly separated from the trunk, which is cylindrical or sausage-like in shape and without any processes. The first two thoracic segments are weakly separated from the rest of the trunk, which is followed by two abdominal segments. The first antenna is bulbous, with a big basal joint which is followed by two small lappets, one of them extending beyond the first antennal joint and the other more to the side. A few short setae were found on the tip of the lappet, extending the proximal joint. The second antenna is two-jointed, strongly uncinate, and of the usual hook shape. The mandibles are two-jointed, falciform, and toothed along both margins. Both upper and lower lips are free, the upper being the larger and forming a roof over the mandibles. The maxilla is small and bulboidal, and the first and second maxillipeds are two-jointed, the latter being the larger. The two pairs of thoracopods are fleshy as in chondracanthids, but lack joints and claws as described by Kröyer for his *Blias;* they are also not bifurcated as in *Chondracanthia* and *Acanthochondria*. On the right first thoracopod of one of the two females present there is a small side bud, situated where the bifurcation should take place. This seems to indicate that, in the Chondracanthidae, the bifurcation is of a primitive nature. The second pair of thoracopods is much smaller than the first pair and also lacks bifurcation.

Male: Of the usual chondracanthid type.

Remarks: The most characteristic features of the species are the two-segmented abdomen in the female, the unbranched thoracopods and an absence of processes on the body. It is hoped that additional material can be collected, and thus enable a more detailed description to be published.

Genus **Acanthochondria** Oakley, 1927

Acanthochondria gemina sp. n.

(Figures 14-19)

Locality, Host and Record of specimens: 5 females (4 with males), including holotype, found in the mouth of *Neoplatycephalus richardsoni* at Redhead, near Newcastle, New South Wales. Collected by W. S. Fairbridge, 21.10.1948.

Female: This species has the general appearance of *Acanthochondria bulbosa* Heegaard and *A. spirigera* Shiino. All three have an elongated " head ", a long neck, and a trunk divided into two parts. While in the present case the neck consists of the normal two thoracic segments (each with a pair of appendages) when viewed ventrally, what appear to be three distinct segments can be counted when the copepod is seen in a strictly dorsal view. This is because the capsule of the " head " does not dorsally cover the part on which the mouth appendages are placed. The posterior part of the " head " has ventrally a large bulbous swelling, and on the posterior part of this swelling the mouth opening and its appendages are placed. The " head " itself is, from a dorsal view, of the normal ovate shape. The trunk is, in the acanthochondrian way, depressed dorso-ventrally, and is two-segmented, with a division dividing it into a larger anterior part with swollen convex lateral margins and a smaller posterior segment with more parallel lateral margins. This divisional line is very clearly seen on the ventral side of the trunk, where it makes a rather deep cut in the surface. On the dorsal side of the trunk the division is not so clearly seen, as there the two parts merge more into one; only the lateral margins have the strong incisions on each side. The trunk extends into a posterior lobe on each side, between which the small abdomen is placed in the median line. The abdomen is small, rhomboidal and furnished with a pair of two-jointed limbs—the so-called anal laminae. The first of these joints is the larger, cylindrical in shape and tipped with the smaller distal, conical-shaped joint. The egg-strings are long, about the length of the whole copepod, and consist of many small eggs. The first antenna could not be seen to be two-lobed, as in most of the chondracanthids, but it consists of at least three joints. It is sausage-shaped, and the distal joint is tipped with a single short, thick spine. The second antenna is the usual large hook-shaped organ with a thick, short terminal joint; the large sickle-shaped hook extends it as a second joint. In this species the basal joint is perhaps more visible than usual in the female.

The upper lip is narrow and covers the toothed distal joint of the mandibles, which are falcate, rather thick at the base, and with the second joint shaped in a blade regularly and uniformly cut into sharp denticles. The maxilla is short and triangular, but no spines could be seen on it. The first maxilliped is two-jointed, with the basal joint stout. The exopod of the first maxilliped is only a short narrow bulb, while the endopod is shaped as a forwardly curved stylet with teeth confined to the whole of its posterior or lateral convex margin. The second maxilliped is three-jointed, with a long basal joint followed by a shorter but thicker second joint carrying hairs on its postero-lateral margin, and tipped with the claw-shaped third joint which is curved backwards. On the second joint, underneath the claw, is a large semi-globular and hairy sensory bulb. The two pairs of thoracopods are of the usual bulbous, bifurcated type, of which the first pair is much shorter than the second. No limbs were seen on the trunk proper. The anal laminae are large and two-jointed, but without any setae; they are placed ventrally on the posterior part of the abdomen.

Length of female, 9-12 mm. Egg-strings, 10-15 mm.

Male: The male is the usual pygmy type, less than 1 mm. in length overall, with a well-rounded carapace and, for the family, a large " abdomen " divided into four segments; a small rostrum is seen in front pointing forward between the second antennae. The first antennae are, unusually for males, clearly two-jointed, with relatively large sausage-shaped basal joints tipped with very small and conical terminal joints; no setae could be seen. The second antennae are the usual large hooks, only placed a little more ventrally than in most cases, with soft and large basal joints and strong and hook-shaped distal joints. The upper lip is a transverse lamella covering the mouth-opening from the anterior, including the denticulated stylet-shaped distal joint of the mandibles, which are entirely protected by the lip. The soft cylinder-shaped basal mandibular joint is relatively long, giving strong movability to the cutting part of the mandibles, which thus become a pair of stylet knives on long shafts. The maxilla is very short, as in the female—only a bud without setae or joints. The first maxilliped is two-jointed, with a large basal joint and a smaller claw tipping this joint. The second maxilliped is three-jointed, with a long basal joint, and a shorter second joint which appears to be furnished with a sensitive pad as in the female, and in the same place, but it could not be distinctly seen.

What is called the abdomen in the male is to be considered as the trunk in the female. So the carapace in the male is only the head capsule in the female, and the diminutive abdomen in the female is then coalesced with and absorbed into the trunk in the male. Thus, the male has the anal laminae or caudal rami placed on the posterior tip of this " abdomen " or trunk. This terminology provides a reasonable explanation of the presence of the two " abdominal appendages " on the first two segments; they are the same as the two pairs of limbs on the first two segments of the trunk in the female. These limbs are small, unjointed and unbranched, as is usual in males of the family Chondracanthidae, if they are present.

Length of carapace, 0.3 mm. Length of abdomen, 0.35 mm.

Acanthochondria tasmaniae sp. n.

(Figures 20-26)

Locality, Host and Record of specimens: 1 female, the holotype, and an attached male, the allotype, were found in the mouth of a " Sea Perch " taken on the east coast of Tasmania, 15.7.1909. Australian Museum Reg. No. E. 6796.

Female: This species is short and squarish, with a short neck tapering from the trunk into the short squarish head in front. The head is strongly rounded dorsally, and much narrower anteriorly than posteriorly. The first thoracic segment is very short and pressed in between the head and the following segment, although it has on the ventral side a pair of appendages which appear as if growing out from the head. The following or second thoracic segment is much larger and wider, with a lateral lobe bulging out on each side. The same segment also carries a pair of appendages on its ventral side which is larger than the previous pair of limbs. Following the two free thoracic segments, which in the Chondracanthidae could be called the " neck ", is the trunk proper, with the acanthochondrian division anteriorly, and posteriorly a lateral incision midway along the trunk which makes the structure lyre-shaped and, in this species, very short. The trunk is not so strongly dorso-ventrally depressed as is usual in *Acanthochondria.* Posteriorly it is produced into two lateral lobes, both of which are strongly curved towards the median line of the body, and long enough to touch each other from both sides, leaving posteriorly a short and very small rounded lobe in the median line of the trunk. The genital openings are found on the ventro-lateral side of this small lobe, quite close to the abdomen. From the ventral surface of the short median posterior lobe of the trunk the abdomen is found hanging like a plum; it is small, as is usual in the Chondracanthidae, but whereas the family commonly features an abdomen wider than long or as wide as long, in the present species the length is nearly twice the width, including anteriorly the narrow neck by which it is attached to the trunk. This small abdomen carries a pair of caudal rami or abdominal laminae as a last pair of limbs.

The egg-strings are long—longer than the whole body, and filled with many small eggs.

The first antenna is a long sausage-shaped organ, with a second and third joint springing from the ventral side near its tip which together form a small club stuck to the antenna proper; no setae could be seen on any of the joints. The second antenna is the usual hook—a large and horny sickle-shaped structure with a very short basal joint. The upper lip is nearly semi-circular and somewhat withdrawn. It looks like a large roof for the mouth-opening and the first mouth appendages, as it reaches down towards the first maxillipeds. The mandible is of the usual blade pattern regularly cut into sharp denticles at its margins and carried on a shaft (the proximal joint). The maxilla consists of a bulbous basal joint from which extend two following joints which are very thin and delicate, the most distal one ending in a point. The first maxilliped is three-jointed, with proximally two cylinder-shaped joints of about equal length, followed by a terminal joint which is conical, pointed towards the tip, and with two rows of stiff tooth-like hairs placed at the anterior and posterior margins. The second maxilliped is also three-jointed, the proximal joint being the largest and more than twice as long as the following one. The second joint is furnished at its distal end with a semi-circular sensory bulb, and the joint is tipped with a backwardly-curved claw.

The first thoracopod is short and bifurcated, with the length of the branches equal to the length of the stem; no joints could be seen. The second thoracopod is larger, and has a longer stem before the bifurcation; the trunk part has no appendages. The caudal rami on the abdomen are two-jointed, placed midway on the side of the abdomen, and each consists of a small basal joint tipped with a backwardly-curved pointed claw.

Length of female, about 4 mm. Length of head, 1 mm. Greatest width of head, 1.2 mm.

Male: The male is the usual tiny dwarf, with a semi-globular carapace or head capsule which is extremely flattened ventrally. The trunk is comprised of only three segments which can be very clearly seen from a dorsal view, but their sutures progressively become weaker and finally lost along the lateral side of the body. The first antenna is small. The second antenna is the normal big, two-jointed, hook-shaped organ, with which the male clings to the female. Between the right and left second antennae the carapace is produced into an exceptionally long rostrum with a rounded tip and parallel sides. The shape of the rostrum, as seen in Fig. 25, is characteristic of the species, and from it the male can be readily recognised.

The mandible is the usual sickle-shaped, two-jointed stylet on a shaft, and cut into sharp denticles on the blade. The maxilla is small and two-jointed; the basal joint compares with that of the female, but instead of having two distal joints, only a single conical claw could be seen. The first maxilliped is two-jointed, and has a big bulbous basal joint furnished with a sickle-shaped claw which has a tip pointing forwards. The second maxilliped is three-jointed; it has a long and muscular basal joint, followed by a thinner and shorter cylinder-shaped joint on which the sensitive pad is placed. Whereas this last is a club in the female, in the male it appears to be a ring running round the distal part of the joint. The terminal joint is a weak, backwardly-curved claw. No appendages are to be found on the free thorax; only at its posterior tip are the caudal rami or anal lamina found. These are two-jointed and clearly indicate that they have originated from proper limbs.

The male is about 0.4 mm. long. The carapace, or head capsule as it is called in the female, is 2.5 mm. long and 1.7 mm. high. The abdomen is about 0.14 mm. long and averages 0.1 mm. in height.

Alimeda orientalis gen. and sp. n.

(Figures 27-36)

Locality, Host and Record of specimens: 3 females, including the holotype, from gill flaps of a Sea Hare, *Aplysia*; Port Jackson, New South Wales. Australian Museum Reg. No. P. 11570.

Female: The cephalon is coalesced with the first thoracic segment; except where produced anteriorly into a blunt rostrum, it is nearly circular in shape. The following four free thoracic segments are elliptical in shape, narrow where each comes into contact with segments in front and behind, but bulging out in the middle to their greatest width. While reduced in size towards both extremities, the first free segment (second thoracic segment) is even wider than the cephalothorax. The genital segment is small, elliptical and followed by the abdomen, which consists of four segments about equal in size and shape. The anal laminae are well developed and each is furnished with two long setae. The egg-strings are sausage-shaped, with many small eggs in several rows.

The first antenna is long, slender, and consists of eight joints. The first and third joints are short, with a long second joint in between which is the longest of all. The fourth and fifth joints are of medium length, and both of the same size. The three terminal joints gradually shorten distally. All the joints except joint number three, which is naked, are furnished with two or more setae, the three setae tipping the terminal joint being very long.

The second antenna has a bulbous stem consisting of three joints which taper in size both proximally and distally. The distal joint is furnished with a one-jointed exopod and endopod, each furnished with a nearly straight claw. A few setae are found distally on the second and third joints. The upper lip is a transverse membrane with a lunular cut placed posteriorly from its middle. This, together with the following mouth-parts, is of interesting shape because both show in all details such a close relation to the mouth-parts of the Chondracanthidae. The mandible is a long and sickle-shaped stylet with a row of teeth on its convex margin. The maxilla is vestigial, as in the Chondracanthidae, and is here only a small pointed palp. The first maxilliped is a flattened one-jointed appendage, with a toothed posterior edge; it shows clearly that the unjointed shape is not its primary shape, but is brought about by the coalescence of at least two joints. The second maxilliped is three-jointed, with a large basal joint, a medium-sized middle joint and a small conical third joint.

The thoracopods all have a single basal joint, and the three first pairs have both a three-jointed exopod and an endopod. In thoracopod number four the exopod is still three-jointed, but the endopod consists of only two joints. In the fifth thoracopod there is present only a one-jointed exopod, and the endopod is reduced to a small process with a seta placed on the protopod; on the lateral side of the exopod and on the distal joint of the endopod short bulbous setae were found which, from their shape, most likely have a sensory function.

Remarks: This interesting species shows, in the mouth-parts and partly in its habitat, a clear relationship to the Chondracanthidae. While it and the members of the Chondracanthidae may have had the same ancestry among free-living forms, their life-histories today are different. The Chondracanthidae are all parasitic in the gill-cavities of fishes, whereas *Alimeda* has been found parasitic in the gills of a mollusc. Furthermore, this new species is of great interest because, in contrast to *Alimeda*, most of the known copepods parasitic on invertebrates have their mouth-parts much more reduced. It is therefore hoped that *Alimeda* and other closely-related genera from invertebrates, when they are better known, may clear up many points about this group's relationship. It is also hoped that, in the near future, some more material of this interesting new copepod can be examined and will reveal the yet unknown male. Most likely the male will prove to be either a pygmy, as in the Chondracanthidae, or one which reaches only the copepodit stage in which it fertilises the female, as in *Lernaea*. In either case the male will prove to be less deformed than the female, and through its morphological characters will indicate its position taxonomically. The new evidence will also most likely cause the creation of a new family. For the time being, until further knowledge is gained, *Alimeda* is placed as an appendix to the Chondracanthidae.

III Suborder CALIGOIDA

Family Caligidae

Genus Caligus Müller 1785

Caligus rapax H. Milne-Edw.

Caligus rapax H. Milne-Edw., 1840, p. 453, pl. 38, figs. 9-12.

Caligus elongatus H. Milne-Edw., 1840, p. 454.

Caligus rapax, Baird, 1850, p. 270, pl. 32, figs. 2-3; *Id.*, Kröyer, 1863, p. 71; *Id.*, Wilson, 1905, p. 568, pl. 7, figs. 79-89; *Id.*, Heegaard, 1947b, pp. 96-99, figs. 36-49.

Locality, Host and Record of specimens: About 20 females parasitic on a Skate (*Raja*); Oyster Bay, Tasmania, 15.7.1909. Australian Museum Reg. No. E. 6792.

Remarks: This species is the most common caligid in the North Atlantic area on both sides of that ocean. It is also the one that has been found on the largest number of different hosts, due possibly to the fact that both the males and females are more lively than in most species, and they frequently display this activity by leaving a host and swimming freely about. This happens more often at night than during the daytime, as evidenced by several investigators who have recorded the capture of both sexes in tow nets, together with non-parasitic copepods.

The present record appears to be the first from waters outside of the Atlantic Ocean and adjoining seas. Now that the species has been found off the Tasmanian coast, it can be expected to be later recognised from New Zealand and along the South Australian coast.

Caligus alveolaris sp. n.

(Figs. 37-44)

Locality, Host and Record of specimens: A few specimens of both sexes, including the holotype, taken from skin of a Mackerel Tuna (*Euthynnus allitteratus*) at Howick Islands, North Queensland. Collected by A. G. Nicholls, 5.11.1948.

Female: The female is about 5.5 mm. long, and has a quadrangular carapace 2.5 mm. long and a little more than 2 mm. wide. The frontal plates are wide and prominent and are not emarginate at the centre. They have large lunules which are almost circular and slightly projecting. The frontal margin between the lunules is nearly straight. The posterior sinuses are narrow and quite deep, leaving the median lobe nearly two-thirds of the entire width. The lateral lobes are narrow and curve a little inward.

The free thoracic segment is transversely linear—in the female about two-thirds as wide as the genital segment, but rather short. The genital segment is square (about 1.3 mm. long and wide) and provided with two short and blunt posterior lobes. The abdomen is nearly as long as the genital segment and made up of two segments of about equal length and 0.5 mm. in width. The terminal segment is deeply hollowed on each side posteriorly for the reception of the small, lateral anal laminae. These latter are flattened and do not reach beyond the tip of the abdomen; they each carry three long plumose setae posteriorly and a much shorter one on the outer margin. The egg-strings are short, only a little longer than the abdomen with the width of the egg-cases about half the width of the abdomen.

The first antennae are a little longer than the frontal plates; the proximal joint of each is a little longer than the distal one and much stouter. The second antennae are short and stout, with a broad terminal claw and a blunt accessory spine. No trace could be found of the first maxillae. The second maxillae are stout, broadly triangular and nearly as long as the mouth-tube; a small one-jointed palp without any setae is found at each of the basal joints. The mouth-cone is short and broadly U-shaped. The furca is Y-shaped, a little rounded at the base of the branches, and with the peduncle longer than the branches; a ridge runs underneath it across the sternum. The first maxillipeds are of the ordinary type. The second maxillipeds are three-jointed, with a slender claw and with an accessory spine; they also carry a short hooked spine on the median side of the proximal joint.

The first thoracic legs are tipped with the usual three claws, and a seta at the inner distal corner between the three terminal claws and the three posterior setae. This seta is shaped more like a spine. The claws are short and stout, all of the same length, and the second and third are on the convex side, fringed with a lamina or wing which is sharply serrate. The second and third legs are ordinary. The large spines on the exopod of the second leg are strong, with the proximal one nearly straight, and the spine on the exopod of the third leg is also stout, with a brim of hairs on the convex side. The fourth legs are large, stout and four-jointed, with the usual five spines; the spines on the second and third joints are larger and longer than usual, but all are smooth and a little curved. The fifth legs can be seen as small bulbs with short setae on the usual place, distally on the ventral side of the genital segment.

Male: The male is a little smaller, due to the reduced size of the genital segment and the abdomen; the carapace itself is nearly equal in size to that of the female. The genital segment is a little wider than long—width about 0·9 mm., length about 0.7 mm. The abdomen is two-jointed, with the proximal joint very short.

In the appendages the usual sexual dimorphism is apparent. The second antennae are a little stronger than in the female and have a stronger accessory spine, but still carry hook-shaped distal joints. Similarly, the second maxillae are more pointed, and the second maxillipeds are much stronger and stouter. The genital segment is furnished with vestigial remnants of both the fifth and sixth legs. The furca in the male is more open in its two branches.

Remarks: This species looks very like the young of *C. coryphaenae* (see Heegaard 1948), but it is smaller and with accessory spines on the second antenna and second maxilliped. It differs further in the shape of the spines on the first, second and fourth legs.

Caligus maculatus sp. n.

(Figs. 45-53)

Locality, Host and Record of specimens: This species is a parasite on the skin of the Queensland Mackerel (*Scomberomorus queenslandicus*), but is found more commonly on the Spanish Mackerel (*S. commerson*); Cape Bowling Green, North Queensland, 2.11.1948; Cape Melville, North Queensland, 5.11.1948; Cape Direction, North Queensland, 6.11.1948; Princess Charlotte Bay, North Queensland, 6.11.1948; Stephens Is., Torres Strait, 23.11.1948 (including the holotype). All the specimens were collected by A. G. Nicholls. Both sexes are represented in the series.

Female: Carapace elliptical, one-fifth longer than wide. The frontal plates are distinct; they have a slightly rounded frontal margin with an emargination at the centre. Lunelus large, semi-circular and prominent. The posterior sinuses are narrow but deep, with a strong lateral incision at the bottom, and the distal parts have approximately parallel sides. Thoracic area broad (three-fifths of the entire width), well rounded, and projecting posteriorly to about the depth of the sinuses beyond the lateral lobes. These latter are narrow and nearly parallel, the median lobe being wide—about two-thirds of the entire width of the carapace. The free thoracic segment is very wide—half as wide as the carapace, with which it is connected by a narrow neck. The genital segment is large, more or less quadrilateral, with rounded corners. It is slightly wider than long, and postero-laterally produced into two quadrangular lobes.

The abdomen consists of two segments nearly equal in size; both are quadrangular and have the same width as length. In the young female and in the male the first abdominal segment is only half the length of the second segment; and towards the free thoracic segment the genital segment has a short, transversely wrinkled neck. The anal laminae are of good size, and terminated by one short and three long plumose setae, the longest being about three times the length of the laminae. The egg-sacs are rather long for a *Caligus*.

The first antennae are short, with only few setae on the terminal joint as well as on the tip of the distal one. The second antennae are stout, placed a little to the side and anteriorly to the mouth-cone. The antennae are three-jointed with a strongly shaped, elongated hook, and a short and wide supplementary hook on the posterior margin of the basal joint. The mouth-cone is plump and short, with a quadrilateral opening fringed by the usual long setae. The mandibles are stout and strongly curved, a condition due to the plump width of the mouth-cone.

The first maxillae are small but two-jointed, with a short basal joint and a hook-shaped, strongly curved distal joint. The second maxillae are prominent, with a large conical basal joint provided with a stout short palp; a second joint is pointed and only a little curved away from the mouth-cone, with its tip reaching beyond the mouth-cone. The first maxillipeds are as stout as the rest of the limbs, with two very unequal curved claws at the tip, and a small accessory claw behind them on the lateral margin. The second maxillipeds are failry stout; the basal joint is much swollen, with a knob for the tip of the second joint to clutch against. The furca is open and cut wide beyond the centre, with the branches nearly twice as long as the base; the latter is much swollen and has two processes—one at each side of the peduncle and coalesced with it.

The first thoracic legs are of the usual form, tipped with the three claws and a seta placed at the inner distal corner between the three terminal claws and the three posterior, plumose setae. The claws are long, a little delicate, and only a little curved. The second joint or basis of the second pair of swimming legs is very stout, and with an anterior wing or process. The claw of the first exopodal joint is exceptionally long—nearly twice as long as the second joint; the claw of this joint is also large—about the length of the joint. The second joint of the endopod in the same limb is characteristically S-shaped and has a fringe of hairs on its anterior free margin.

The second pair of swimming legs is furnished with a large plate-shaped protopodite, with the two branches sitting close together. While both exopod and endopod are large they are of normal shape. The fourth pair of swimming legs are three-jointed, the basal joint being a little longer than the combined length of the two following ones. The second joint is tipped with a claw which is the longest of the five claws of the appendage. The last or terminal joint is a little longer than the previous one and is tipped with three smaller claws, the most distal one being the largest, and the other two a little shorter and of about equal size. The fifth claw is placed on the lateral margin of the terminal joint, half-way between the claws at the tip and the claw on the previous joint. At the base of each claw is a fringe of stiff hairy setae which is characteristic of the species, and of good systematic value. No fifth legs were found on the female.

Total length, 6 mm. Length of carapace, nearly 3 mm. Width of carapace, 2.25 mm. Length of genital segment, 1.5 mm. Width of posterior processes, a little more than 2 mm. Length of abdomen, 1.2 mm.

Male: The male is extremely large—nearly as long as the female. The carapace is even larger than that of the female and a little wider. The genital segment is only small, acorn-shaped and, as in the female, has a short neck towards the free thoracic segment. The abdomen is two-segmented, the first segment being less than half the length of the second. All the limbs are stout. The second antennae are of the typical male type, with the terminal claw coalesced with the previous joint, on which a triangular-shaped accessory spine is placed against the tip of the claw. Both first and second maxillae are much stouter than in the female; the second maxillae, as in the female, are furnished with a palp, but that of the female is a little shorter. The second maxillipeds are stouter than those of the female. On the genital segment of the male a fifth pair of legs is present as small processes with two setae, which can even be seen from the dorsal side.

Total length, 5 mm. Length of carapace, 3 mm. Width of carapace, 2.5 mm. Length of genital segment, 1 mm. Length of abdomen, 0.8 mm.

Remarks: The species was taken in great numbers. It is a stout caligid, easy to recognise with its spotted body, the fringe of hairs at the base of the fourth limbs, and the large open furca.

Caligus lucidus sp. n.

(Figs. 54-61)

Locality, Host and Record of specimens: Three specimens, including the holotype (both sexes represented), of this species were found attached to the skin and fins of a Chinaman Leatherjacket (*Cantherhines ayraud*) at Cape Hawke, New South Wales, 22.11.1948. Collected by W. S. Fairbridge.

Female: Carapace more than half the entire length, a little longer than wide, and narrowed anteriorly. Frontal margin a little rounded; frontal plates dominant, but with rather small lunules placed an appreciable distance from each other. Posterior sinuses shallow; lateral lobes narrow and a little pointed at the tip. Lateral aleae of carapace very large, with rounded corners, and projecting well behind the lateral lobes. Thoracic area of carapace very large, about three-fifths the length of the carapace.

The free thoracic segment is short and less than one-fourth the width of the carapace. The genital segment is a little less than two-thirds the width of the carapace and half its length; it is oblong in shape, has well-rounded corners, and two smaller posterior processes nearly as long as wide. The abdomen is nearly as long as wide. The anal laminae are large, close together, and each is tipped with three long, and one short, setae.

The first antennae are large, with a stout basal joint, and a conical distal joint with the top of the cone towards the proximal joint; the first joint is furnished with several spiny setae, and the second joint is tipped with thinner setae, some of them quite short.

The second antennae are large, with an elongated basal joint, the hook being divided by a suture into two parts. The first maxillae are two-jointed, with a short basal joint coalesced with the carapace, and a second joint shaped in a stout hook only a little curved. The second maxillae are characteristic of the species. They are two-jointed, with a short basal joint coalesced with the carapace and furnished with a two-jointed palp. The second and distal joint is blunt and tipped with a little knob. The mouth-cone is short and stout.

The first maxillipeds are longer than usual, and have a stout basal joint; the distal joint is narrow at its base, becoming flattened and widened towards the tip, like the blade of a knife. The two claws at the tip are long and very delicate, the most distal one being twice as long as the other; both are placed at the most distal corner of the joint. Further, an accessory spine of normal shape and size is found in the normal place on the distal joint. The second maxillipeds are extraordinarily small; the basal joint is only a little swollen, and the hook is very delicate and less than half the length of the proximal joint. The tip of the claw is separated from the rest by a line.

The furca is large and with flattened branches, the whole having the appearance of the head of a long-eared bat. The furca has a rounded Y-shape, the base being of the same length as the branches, but much wider. The branches themselves are very stout, blunt, and only slightly diverge. The basal portion is very narrowed at the centre, widening out considerably towards the carapace like an hour-glass.

The first pair of swimming legs is of normal size, and tipped with three delicate and curved claws; the seta at the distal corner, between the claws and the plumose setae, is lacking. The plumose setae are specially shaped; each of them is swollen at the base, and on the lateral side of this bulb a fringe of hairs can be seen—the remaining part of the setae is of the usual plumose shape. The second and third pairs of swimming legs are of very ordinary shape, with no characteristics whatsoever. Only in the third pair is there to be found a good distance between the two branches, of which the exopod especially is a little larger than usual. The fourth pair of swimming legs is two-jointed, long and slender, and furnished with four claws. The claws are delicate, exceptionally long, and both are a little bent and curved, preventing them from functioning as normal claws. Three of the claws are placed most distally on the second joint; the fourth is placed midway along the margin of the same joint, indicating that this joint must be a coalescence of two joints. The anal laminae are long and each is tipped with one short, and three long, setae.

The egg-strings are long, with a row of thick eggs.

Total length, 4.8 mm. Length of carapace, 2.7 mm. Width of carapace, 2.4 mm. Length of genital segment, 1.3 mm. Length of abdomen, 0.4 mm.

Male: The male is of nearly the same size except that, as the genital segment is much smaller than in the female, the whole copepod is a little shorter (about 4.5 mm.). The carapace is a little larger, and the genital segment much smaller, than in the female. The latter is acorn-shaped and furnished with both a fifth and sixth pair of limbs on its ventral side which are, as usual, very vestigial and can be seen as small bulbs with, respectively, three and two setae. The abdomen is two-segmented, each segment a little shorter than the abdominal segment of the female, and of equal size. The setae of the abdomen may be a little longer than they are in the female. The limbs are exceptionally weak for a male; even the second maxillipeds are not larger than those of the female.

Remarks: The whole animal is hyaline, a condition which has suggested its specific name; in other features also it is very characteristic and easy to recognise—the shape of the second maxilla and the two maxillipeds, as well as the furca, and the plumose setae on the fourth pair of swimming legs. In general appearance the species is somewhat like *C. alatus* (Heegaard 1943) but the differences in the limbs are numerous.

Caligus dentatus sp. n.

(Figs. 62-67)

Locality, Host and Record of specimens: One female, the holotype, taken on the Spotted or Japanese Spanish Mackerel (*Scomberomorus niphonius*) at Dalrymple Island in Torres Strait. Collected by A. G. Nicholls, 23.11.1948.

This is one of three small caligid species of which only a single specimen (a female) is known and recorded here.

Female: Carapace orbicular, somewhat narrowed anteriorly, with rounded sides and as long as wide. Frontal plates well developed and prominent; the lunules are small, circular and almost entirely concealed in dorsal view. Posterior sinuses narrow; the median lobe is a little less than half the entire width, and not projecting behind the well-developed lateral lobes, which are curved a little inward. The cephalic part of the carapace is nearly twice as long as its thoracic portion.

The free thoracic segment is very narrow, less than a third of the width of the carapace and much constricted in front of the fourth legs. The genital segment is elliptical, only half as wide and nearly as long as the carapace, and projects posteriorly in the form of a blunt, conical lobe on each side of the abdomen. The abdomen is two-segmented; the first segment is a little shorter than the following one, and together they are only a little shorter than the genital segment.

The anal laminae are long and narrow and inclined towards each other; they bear three long and one short terminal setae. No egg-strings were found on the specimen.

The first antenna has a very stout first joint, as long as the width of the lunules; it is provided with a fringe of short thick sensory hairs on its frontal margin. The second joint is of moderate length; it is provided with some short spiny hairs and some longer flexible ones, the latter being placed on the posterior margin of the joint near to the tip. The second antenna is three-jointed and characteristically slender, terminating in a very slender curved hook. The mandibles and the mouth-tube are of the usual type. The first maxilla is small and two-jointed, with the distal joint shaped in a slender claw; no palp was seen on the proximal joint. The second maxilla has one free joint which is strong and pointed, but a proximal joint is present which is coalesced with the carapace, forming a ridge from the mouth-cone and towards the lateral margin. The maxillary palp is present on the latter as a two-jointed bud. The first maxilliped is of the usual pattern but with a very stout basal joint, and the anterior claw is much stronger than the posterior one. The second maxilliped is very stout for a female and three-jointed; the basal joint especially is very stout and furnished with powerful muscles and a long two-jointed and strongly curved terminal claw. The two joints in the claw are probably due to age, as they are often found in young specimens; later the joints coalesce so completely that no suture can be seen between them. The furca is a delicate long fork with a bulb at the base, followed by a short delicate peduncle and two long slender branches which are blunt and curved in towards each other.

The first swimming legs are slender, with three terminal claws. The most distal claw is the strongest and the most proximal one the weakest, but all three are delicate. The usual seta at the corner is well developed. The usual three plumose setae on the posterior margin of the terminal joint are missing, with no trace of them left.

Along the anterior margin of all three exopodal joints of the second pair of swimming legs a wing is present, and on the endopod both the first and the second joints have serrated anterior edges, a feature which has given the species its name.

The rami of the third legs are placed close together; on the basis a wing is found, reaching from the base of the exopod and along the lateral margin of the joint.

The fourth legs are long but very delicate, the basal joint being nearly as long as the two terminal ones; of the four spines, the largest is at the tip of the second joint, and smaller ones occur on the outer margin of the terminal joint and at the tip. The last two spines were broken off in the single female found in the collection but, judging from their bases, they could only have been small.

Total length, 4.2 mm. Length of carapace, 2 mm. Width of carapace, 1.7 mm. Length of genital segment, 1.3 mm. Length of abdomen, 0.85 mm. Egg-strings not present.

Caligus proboscidatus sp. n.

(Figs. 68-74)

Locality, Host and Record of specimens: Cape Bowling Green, 2.11.1948. Princess Charlotte Bay, 6.11.1948. Eden Reef and Princess Charlotte Bay, 6.11.1948 (including the holotype)—all North Queensland. Collected by A. G. Nicholls, from the mouths of mackerels (*Scomberomorus queenslandicus* and *S. commerson*)—a total of 5 young males; no females were found.

Male: Carapace about four-sevenths the entire length, longer than wide, and not narrowed anteriorly. Frontal plates well defined, a little more than half the width of the carapace. The lunules are large, circular, and projecting a little. Posterior sinuses wide, and slightly inclined away from the central axis. The median lobe is about half the entire width of the carapace, and projects only a little beyond the lateral lobes; the latter are blunt and well rounded.

The thoracic area is of medium size, the anterior groove being almost linear across. The free thoracic segment is transversely linear, wider than the genital segment, and very short. The genital segment is contracted into a short, narrow neck where it joins the free segment, and is wrinkled across this neck as though segmented. It is about one-and-a-half times longer than wide, and is narrow towards each end, its extreme width being less than one-third of that of the carapace. The abdomen is nearly as long as the genital segment. It is two-segmented, the segments being approximately the same length. The anal laminae are small, well separated and straight, and each has three plumose setae. The anterior antennae are short and closely depressed to the carapace. The second antennae are stout, with a strongly curved terminal hook.

The first maxillae are of medium size, with a slightly curved pointed tip and an enlarged base. The second maxillae have a stout basal joint with a little palp and a pointed, curved distal joint. The mouth cone is extraordinarily long, appearing much like that in the Pandaridae. The first maxillipeds are stout, with two short, curved terminal claws. The second maxillipeds have an exceptionally stout basal joint even for a male, and the slender strongly-curved distal joint is furnished with two accessory spines. On the proximal joint also, some spiny knobs are present at the point where the tip of the distal joint touches. The furca is small, Y-shaped and slender; its base is elongate, very narrow and about as long as the branches, which are divergent, rather slender, and blunt.

The first swimming legs are slender, with the usual terminal claws, but are very weak, and so is the seta at the corner. The usual three large plumose setae on the posterior margin of the terminal joint are missing; three small spines are found in their place. This is unusual, although in the present Australian material the same condition is also found in *C. obovatus*. In *C. dentatus* this same posterior margin is even naked. A further feature common to all three species is that they are small and a little delicate.

The claw on the proximal joint of the exopod of the second legs is long and curved; on the following joint the claw is very small. On the third exopodal joint the claw is short, and fringed on each side from the base to the tip with a lamina or wing. The frontal side of the second endopodal joint is fringed with a dentated wing or lamina, which is not found on either the previous or succeeding joints. The rami of the third legs are large and stand out prominently from the edge of the basal lamina. The fourth legs are short but very stout, three-jointed, with the basal joint especially very large; the distal joint is the shortest and smallest. The legs have five spines of about the same length situated close together along the outer margin, which are short, curved and dentated on their concave sides. The two proximal claws are dentated from their bases to their tips, and the three distal claws only nearly to their tips on their concave sides. No fifth legs could be seen.

Total length, 2.5 mm. Length of carapace, 1.35 mm. Width of carapace, 1 mm. or a little more. Length of genital segment, 0.6 mm. Length of abdomen, 0.5 mm.

Remarks: Only five males of this species were collected from three different localities. The specimens are all very young, with a little of the frontal filament left from the chalimus stage. The species is easy to recognise by its small and delicate size, the extremely long mouth-cone, the first swimming legs without the plumose setae, the serrated edge on the second endopodal joint of the second legs and the dentated claws, and the spines of the fourth legs.

Female: Unknown.

Caligus quinqueabdominalis sp. n.

(Figs. 75-82)

Locality, Host and Record of specimens: Three females, including the holotype, collected from *Scomberomorus commerson* in Torres Strait by A. G. Nicholls, 22.11.1948.

Female: Carapace orbicular and nearly as wide as long. Frontal plates dominant, with the frontal margin strongly curved. Lunules circular and widely separated, but so small that they can easily be overlooked. Posterior sinuses are shallow and widely triangular. The median lobe is more than one-half the width of the carapace and part of it projects behind the lateral lobes. Transverse groove circular, separating the cephalic from the thoracic areas almost through the centre of the carapace. The eyes are small and placed well forward.

The free thoracic segment is short and quadrangular, and is about half the width of the genital segment. It is very prominently widened at the centre through the base of the fourth leg, and has a narrow neck towards the carapace. The genital segment is two-thirds the width of the carapace and is about a third wider than long, with strongly-curved lateral margins and a somewhat indrawn, concave posterior margin.

The abdomen is of the same length as the genital segment and is five-segmented. The segments are about equal in size, and although the sutures between them are not very distinct, they can be seen without difficulty. The anal laminae are stout, and armed with small and short setae.

The anterior antennae are short—about two-thirds as long as the frontal plates, with the terminal joint a little shorter than the basal one. Both joints are only weakly armed with setae, those on the terminal joint being gathered at the tip. The second antennae are large, with the basal joint swollen. The terminal claw of these appendages is much elongated, with a short hook at the tip. The first maxillae are close to the tips of the second antennae; they are only small and shaped in a bud with two papillae—one for the following joint and one for the palp. The second maxillae are stout, strongly curved, two-jointed and very pointed at the tip, the first joint being furnished with a palp. The terminal joint projects some distance in front of the mouth-cone; the latter is of usual size or may be a little longer.

The first maxillipeds are of the usual shape, tipped with two strong claws, and have an accessory spine placed laterally on the distal joint. The second maxillipeds are rather small, the basal joint being nearly twice the length of the terminal claw; the latter is stout and strongly curved.

The furca is of medium size, not quite cut to the centre, thus making the branches a little shorter than the base. It is conical in shape, its branches only a little divergent, and ending bluntly. The base is swollen on each side at the centre, giving it a spindle shape.

The first swimming legs have a stout spine on the posterior margin, and a smaller one on the outer margin of the basal joint. The three terminal spines are nearly equal, and the seta on the corner is missing, but the three plumose setae on the posterior margin are rather long and stout. The second pair of legs has a very large spine on the first joint of the exopod, and the spines that follow taper in size towards the third joint. The second endopodal joint has a fringe of hairs on its outer margin. The rami of the third pair of legs are well separated and stouter than in most species. The fourth pair of legs is large, stout and four-jointed; the basal joint is about equal to the combined length of the other three joints, and is very stout and square. The remaining three joints are of about equal length. Joints number two and number three are each tipped with one stout spine. Joint number four is tipped with three stout and slightly curved spines of equal length, making a total of five spines on the leg. No fifth pair of legs could be seen.

Total length, 4.7 mm. Length of carapace, 2.2 mm. Width of carapace, 2 mm. Length of genital segment, 1.1 mm. Length of abdomen, 1 mm. Length of egg-strings, 2.7 mm. Eggs large.

Male: Unknown.

Remarks: The species is very easy to recognise, as hitherto none has been described with five abdominal joints.

Caligus sensorius sp. n.

(Figs. 83-91)

Locality, Host and Record of specimens: Twice found on a small Surf Fish (*Iso rhothophilus*)—once in a rock bathing pool at Long Bay, near Port Jackson, New South Wales, 5.5.1927 (Australian Museum Reg. No. P. 8928), and once at Maroubra Bay, also near Port Jackson, New South Wales, 3.6.1894; Australian Museum Reg. No. G. 5218, many specimens, including the holotype. From scales of "Snook" (*Australuzza novaehollandiae*) in Esperance Bay, Western Australia, no date (Australian Museum Reg. No. P. 5726).

Female: This is only a small species, the general shape of the body being short and stout; the elongated carapace narrows anteriorly and is only a little longer than wide. The frontal plates are dominant, with the frontal margin a little curved. Lunules are semi-circular and widely separated, but not of dominant size; they reach only a little more than half-way across the frontal plates. The posterior sinuses are shallow and a little triangular, with their inner margins inclined slightly away from the central axis, the median lobe being a little more than half the entire width of the carapace and projecting a little beyond the lateral lobes; the latter are pointed and incurved towards the axis. The eyes are only small and placed at a point about one-third along the length of the carapace. The transverse groove is circular, separating the cephalic from the thoracic areas almost through the centre of the carapace.

The free thoracic segment is triangular, with one tip pointing forward. It is very narrow, its width being only one-fourth the width of the carapace. The genital segment is transversely semi-lunar in shape and a little wider than long. Its sides are well rounded, the posterior angles being prolonged backward as stout blunt lobes. The posterior margin between these lobes is deeply concave. No fifth or sixth pair of legs are visible.

The abdomen is unjointed; the width at its base is a little more than one-fourth the width of the genital segment. The length of the abdomen is slightly greater than its width. The anal laminae are proportionally of good size, and armed with three small plumose setae and a very short one at the lateral corner.

The joints of the first antennae are elongated and the distal one is a little delicate. Second antennae are of usual size and with an accessory spine at the base of the proximal joint. The first maxillea are long, slender, well curved and two-jointed, but with very little swelling at the basal joint. The second pair of maxillae is simple, with a wide triangular base and a short blunt tip; a small palp is placed at the base. These maxillae are attached opposite the base of the mouth-tube and extend partly beyond its tip. The mouth-tube is short and evenly rounded, and is nearly as wide as it is long. The first maxillipeds are of the usual form, elongated and without an accessory spine. The second maxillipeds are only small, with a long narrow proximal joint, four times as long as it is wide, and with a short terminal joint strongly curved at the tip and less than half the length of the proximal joint. The furca is very characteristic. It is built with a very short peduncle, and two slender branches with an absolutely blunt tip; the branches are nearly parallel but very wide apart, even at their bases.

The first pair of swimming legs is of the usual form, with three terminal claws and three long plumose setae on the posterior margin of the distal joint, but lacking the long and slender seta at the corner. The second and third pairs of swimming legs are normal in all details.

The fourth pair of legs is long and very delicate; the first joint is elongated, very thin and followed by two joints of about equal length, and together they are a little shorter than the proximal joint. The second joint is tipped with one long claw, and the third joint with two claws, of which the most distal is about half again as long as the one behind; the joint itself is extended into a spiny process in front of these two claws. At the base of each of the two distal claws a hairy sensory bulb is found, which has prompted the naming of the species (see figure).

Total length, 3.5 mm. Length of carapace, 2 mm. Width of carapace, 1.7 mm. Length of genital segment, 1.2 mm. Length of abdomen, 0.3 mm. Length of egg-strings, about 2 mm.

Male: The male is much smaller, the frontal plates are more curved anteriorly, and the carapace is proportionally much narrower behind the anterior antennae than in the female.

The free segment is longer than in the female and with a narrow neck towards the carapace. The genital segment is very small and narrowed considerably both anteriorly and posteriorly, giving it a barrel shape. The abdomen is three-segmented, with three equal segments. The anal laminae are as in the female.

Of the appendages, the second antennae are of the shape often found in males, with the short incurved claw. The male second maxillipeds are very much larger and stouter than the same weak and puny appendages of the female; the basal joint is much swollen and furnished with a knob, around which the tip of the terminal claw fits snugly. The terminal claw is about half the length of the proximal joint.

Total length, 2.4 mm. Length of carapace, 1.45 mm. Width of carapace, 1.3 mm. Length of genital segment, 0.4 mm. Length of abdomen, 0.3 mm.

Remarks: This small species was taken in large numbers on the fish it was attacking. Full details of the catch appear in the Australian Museum Magazine, iii, part 4, 1927, p. 129.

The species can be readily recognised, especially by its characteristic furca, the fourth pair of swimming legs with their three claws and two sensory bulbs, and the spiny process at the tip of the distal joint.

Caligus cornutus sp. n.

(Figs. 92-98)

Locality, Host and Record of specimens: 3 males of this large caligid were found on the skin of one of the Australian Pikes, *Sphyraena jello* (?), at Cape York, North Queensland; collected by A. G. Nicholls, November, 1948. 1 male and 1 juvenile female, the holotype and allotype, on *Sphyraena* at Portland Roads, Cape York, North Queensland; collected by A. G. Nicholls, 12.12.1948.

Male: The description of this new species will have to be based mainly on the male, as only one immature female was found. Superficially it is a rather large, stout copepod, resembling *Caligus curtus*, although very different in many important details. The carapace is broad, ovate, as wide as it is long, and somewhat longer than the rest of the body. The frontal plates are distinct and broad; the anterior margin is well rounded and incised at the centre. The two lunules are large, semi-circular to circular in shape, widely separated, and project a little beyond the frontal plates. The posterior sinuses are shallow, elliptical and nearly parallel with the central axis. The median lobe of the carapace is rather wide, about half the entire total width, and reaches to the posterior line of the lateral lobes. The posterior margin of this median lobe is four-lobated, with two larger lateral lobes projecting further posteriorly, and a shorter median part with an incision in the centre. The lateral lobes of the carapace are plump and well rounded. The cephalic area of the carapace is large and more than half the length of the entire carapace; the lateral areas are also large, and the thoracic area is a little wider than long, pushed backwards and relatively small except for the part merging with the large median lobe. The fourth free thoracic segment is large and very wide—about one-third the width of the carapace. Posteriorly there is a larger median lobe overlapping the genital segment.

The genital segment is globular and of a shape which I have not seen before in any caligid. As it is known, the so-called genital segment is formed by a coalescence of segments five and six. In the male of *Caligus cornutus* this can clearly be seen because the coalescence is not complete—reference to the figure of the species will show that there is a distinct line to be seen between the two segments. On the fifth segment there are two large lateral horns, coalesced for most of their length with the lateral margin of the segment, leaving only a furrow in the division between the segment proper and each of the horns. The horns end posteriorly in two backwardly-directed spines—a large one ventrally and a smaller one dorsally. The sixth segment is much smaller than the fifth and forms the posterior part of the genital segment. On the ventral side of the sixth segment is found a pair of spines—the vestigial sixth pair of legs. The abdomen is short and nearly square, a little longer than wide, and terminates in two lateral horns. Only one abdominal joint could be found. The anal furca is stout and short, terminating in three very stout setae and a fourth shorter lateral one, making a total of four.

The anterior antennae are extremely large, with the basal joint very stout and fringed on its anterior margin with short, plumose, sensory hairs. The terminal joint is slender and very long—nearly as long as the basal joint, and tipped with a few setae. The second antennae are of the usual hook-shaped type and three-jointed, with the proximal joint coalesced with the body.

The mandible is of the usual type, with the mouth-cone short and strong. The first maxilla is of fairly large size and situated nearly in line with the second antennae. Its first joint is absorbed in the body, but the second joint is provided with two spines, the endopodal one tipping the joint and the exopodal one forming a bulb or nub on the side of the free basis joint

The second maxilla is placed behind the second antenna, close into the mouth-cone. It is three-jointed, with a basal joint followed by two endopodal joints, which show some variation in their size and shape; they are yellow and horny, and together they take on the shape of a spine. In the figure of the species the distal joint is shown as very small, but in some specimens it is larger by comparison with the previous joint. This distal joint not only varies in different specimens, but may even differ with the right and left maxilla of the same specimen. The first and terminal joints are supplied with a vestigial two-jointed exopod, shaped as a small spine.

The first maxilliped is of the usual type, with the distal joint much longer than the proximal one, and furnished with a short conical accessory spine besides the two terminal ones. The second maxilliped is of average size, with an accessory spine on the second joint, and a claw-like ridge on the medial side of the proximal joint for the subchela to close against. The sternal furca is stout and wide in the gap, and has a rounded wing on each side; being very short, it cannot be raised very much from the body.

The first thoracic legs are large and stout, the first joint being provided with a short spine at its distal end—the vestige of the endopod. The next two joints are large, the second one nearly twice as long as the proximal one, and with a fringe of hairs at the postero-medial margin. The terminal joint is much shorter, and tipped with three claws which have a row of teeth on their posterior concave margin; the claws are swallow-tailed and split into two points at their tips. The same joint lacks the seta which is sometimes found at its inner distal corner between the three terminal claws and three posterior setae. The latter are strongly plumose, especially the most distal one, the side of which, towards the claws, is strongly asymmetrical, with much longer hair towards the claws than towards the setae on the other side.

The second pair of swimming legs has a distinct coxa and basis, the coxa being short, with a single plumose seta; the basis is about three times the length of the coxa, strong and stout, and tipped with an exopod and endopod, each with three joints. The first and second exopodal joints are each furnished with a claw and a plumose seta. The third and distal joints of the exopod have two claws and six plumose setae; the latter, together with the endopod, forms an effective swimming fan. The first and second endopodal joints are each furnished with one large plumose seta and their margins are fringed with hair; the second joint has, in addition, a lobate wing at the postero-medial margin. The third and distal endopodal joint is small, but is fringed with seven large plumose setae. The third pair of swimming legs has quite widely separated rami; the claw of the exopod is large and curved. The two free distal joints of the exopod and endopod have their antero-lateral margins fringed with hairs. The fourth pair of legs is four-jointed, the second and third joints being tipped with strong and nearly straight claws. The three claws on the fourth joint are curved. All five claws have a fringe of hair at their bases. The fifth pair of legs is rather peculiar in that each leg extends from the genital segment to a point about one-fifth of its length from the anterior margin, or to one-third of the fifth segment; they each have a proximal joint and two spines, the joint lying in such a position as to appear like a lateral frame to the genital segment, and grown together for its full length, with only a furrow showing the line of coalescence. This basal joint is tipped with two free claws. The endopod is the larger one, and is in a dorso-lateral position to that of the smaller exopodal spine. On the ventral side of the sixth segment two spines are found, representing the sixth pair of thoracic limbs.

Total length, 6-7 mm. Length of carapace, 3.5 mm. Width of carapace, 3.2 mm. Length of genital segment, 1.5 mm. Width of genital segments, 1.5 mm. Length of abdomen, 0.8 mm.

Female: The single young female of the present series is little advanced beyond the last copepodit stage, with the genital segment not fully developed (see figure). It is therefore not possible to record a full description of a female specimen. All that can be mentioned is that the horns found on the genital segment and adbomen of the male are absent in the young female. Further, the two pairs of spines on the genital segment of the male, representing the limbs, are in the female each developed into only one bristle—the fifth placed laterally, the sixth ventrally, as shown in the figure.

Remarks: The characteristics of this species are a relatively large and plump caligid type of body, with well-developed first antennae; vestigial exopods on both first and second maxillae; short, wide and strong sternal furca, with aleae on the lateral borders; bifurcated spines on the distal joint of the first thoracopod; a glogular genital segment clearly divided into two segments; a fifth pair of legs shaped like lateral horns on the genital segment; and the one-segmented abdomen extending into two postero-lateral horns. By these characters the male should be very easily recognised.

Caligus obovatus sp. n.

(Figs. 99-105)

Locality, Host and Record of specimens: Off Palm Island, North Queensland, 2.11.1948; Cape Bowling Green, North Queensland, 2.11.1948; Cape Melville, North Queensland, 5.11.1948; Cape Direction, North Queensland, 6.11.1948; Princess Charlotte Bay, North Queensland, 6.11.1948; Eden Reef and Princess Charlotte Bay, North Queensland, 6.11.1948.; Torres Strait (from two localities), 22 and 23.11.1948; 11 specimens, including the holotype. All the hosts were Mackerels, *Scomberomorus queenslandicus* and *S. commerson*, and all specimens were collected by A. G. Nicholls.

Of the large series of specimens from eight different localities, all were males; no females were found. The species is much like the previously described *Caligus proboscidatus*; it was found on the same hosts and at the same localities. Although there is a close likeness, some important differences exist, and there can be no doubt that two distinct and valid species occur on the same hosts.

Male: The circular shape of the carapace is characteristic; it is as long as wide, and more than half the entire length of the copepod. The frontal plates are well defined, but their combined length is less than half the width of the carapace. The lunules are large, circular and projecting. The posterior sinuses are wide and slightly inclined away from the central axis, the median lobe being much less than half the entire width and projecting only a little beyond the lateral lobes; the latter are pointed and strongly incurved towards the axis.

The thoracic area is large, its length equal to nearly two-thirds of the entire carapace, and the anterior groove is almost a perfect semi-circle. The free thoracic segment is short and narrow, about one-fourth the width of the carapace, and contracted into a much-narrowed neck just in front of the basis of the fourth legs. The genital segment is also contracted into a short, narrow neck where it is joined to the free segment, the same as is found in *C. proboscidatus*. It is also wrinkled across this neck as though segmented. The neck itself is about one-third longer than wide and narrow towards both ends; its extreme width is about one-fourth of that of the carapace. The abdomen is a little longer than the genital segment, is two-segmented, and the segments are of approximately the same length. The anal laminae are large, and as wide as long. They are somewhat curved in towards each other, and tipped with three strong, plumose setae and a small spine on the distal corner.

The anterior antennae have a stout proximal joint and an elongated distal joint. The second antennae are shaped as in some males, with the two first joints more elongated, and with the hook short, strongly curved and partly coalesced with the proximal part. The first maxillae are very large, with the short proximal joint carrying a small palp. The second joint is very large, hook-shaped and pointed—larger than is known in any other caligid. The second maxillae are of medium size, with a palpiform seta on the proximal joint and a little curved and pointed distal joint. The first maxillipeds have stout proximal and distal joints; the distal joint of each is tipped with the usual two strongly-curved claws, the frontal of which is twice as long as the one behind. The second maxillipeds have a stout, square basal joint, with two knots where the point of the second joint touches the proximal one. The distal joint is stout and curved, and has a small accessory spine. The furca is small, its branches being about the same length as the base. The latter are considerably divergent, and have blunt tips. The lumen between the branches of the furca is broad and trapezoid.

The first pair of swimming legs is slender, with three weak terminal claws; the seta at the corner is slender and elongated. Of the plumose setae, only two are left, both very short and delicate. And of the third and most distal plumose seta, only a diminutive spine is left.

The second pair of swimming legs is very much like those found in *C. proboscidatus*, only the claw on the second exopodal joint is not small, but of normal size; the second endopodal joint also has a dentated lamina, as in *C. proboscidatus*. The rami of the third legs are small and a little delicate, as also is the spine at the base of the exopod. The fourth legs are short, weak and three-jointed, and have five spines of about the same length. The four distal spines are situated close together along the outer margin of the distal joint, and all are a little delicate. The fifth spine is placed a little further back on the second joint, and is a little stouter. The two terminal joints of the fourth legs are of about the same length. No fifth legs were seen.

The size of this species varies considerably, but the specimens averaged about 4 mm. in total length. Length of carapace, 2 mm. Width of carapace, 2 mm. Length of genital segment, 0.7 mm. Length of abdomen, 70.8 mm.

Remarks: This species was found with the previously described *Caligus proboscidatus*, to which it is closely related. There are, however, several distinct differences which clearly separate them. *C. obovatus* has the wider carapace and remarkably large first maxillae compared with those of normal size in *C. proboscidatus*. On the other hand the mouth-cone is very large in *C. proboscidatus*, but of medium size in *C. obovatus*. Still further differences are to be found, especially in the second maxillipeds, in the furca and in the first, second and fourth swimming legs.

Female: Unknown.

Caligus longirostris sp. n.

(Figs. 106-115)

Locality, Host and Record of specimens: D'Entrecasteaux Channel, Tasmania, 4.11.1948, collected by A. M. Olsen from *Physiculus barbatus*. Nubeena, Tasmania, 27-1.1949, collected by W. S. Fairbridge, from *Platycephalus bassensis*. Several specimens, including the holotype.

Female: Carapace elliptical, as wide anteriorly as posteriorly, and more than half the entire length. Frontal plates prominent and distinct. Lunules small and widely separated. Posterior sinuses shallow and nearly parallel with the longitudinal axis. The median lobe is more than half the entire width and about the same length as or a little longer than, the lateral lobes, which are narrow and somewhat pointed. The free fourth segment is small and narrow, and has a constricted neck. The genital segment is orbicular or slightly obcordate, a little longer than wide, and with a shallow posterior emargination. It is half the length of the carapace, has symmetrically rounded sides and posterior corners with a distinct fifth pair of legs represented by two setae. The abdomen is unsegmented, a little more than half as long as the genital segment and a little less than half the width of the same, and is contracted at its base. The anal laminae are small, with short setae. The egg-strings are of different length, some of them being twice as long as those shown in the figure; the eggs themselves are rather large.

The basal joints of the anterior antennae are large and stout, with many spiny setae. Their terminal joints are of about the same length and very slender. The appendages as a whole are less than the space between the lunules. Second antennae are of more usual form but have a long and slender terminal hook; their two proximal joints are short and stout. The first maxillae are very characteristic in being three-jointed, and contrary to the usual two- or one-jointed maxillae found in caligids; the proximal joint is fully coalesced with the carapace, but the margins can clearly be seen. Following this is a partly free second joint, and a third joint which is a little curved and blunt. The second maxillae are stout, two-jointed and provided with a small two-jointed palp. The mouth-cone is very long, nearly twice as long as is usually found in species of *Caligus*, but not quite as elongated as in the previously described *Caligus proboscidatus.*

First maxillipeds are stout and large in both their joints. The two terminal claws are curved and very stout. A small accessory claw half-way along the distal joint is in the usual place when found to be present. The second maxillipeds are of medium size, the basal joint being swollen and much elongated. The terminal claw is small, but possesses an accessory spine.

The furca is stout and large, and not quite cut to its centre, making the branches a little shorter than the length of the base. The branches are conical, nearly parallel but widely separated. The base of the furca is swollen on each side at its centre, giving it a spindle shape.

The first swimming legs have a stout basal joint, and each is tipped with only one claw and a long curved seta at the corner, and there are three well-shaped plumose setae on the posterior margin. The spines on the exopods of the second swimming legs are short, and on the frontal margin of each exopod a small wing is present. The spine on the proximal exopodal joint of the third swimming legs is short and only a little curved; the two branches of the legs are well separated. The fourth legs are of medium size but rather short and three-jointed, with five spines; one spine is at the distal end of the second joint, two on the outer margin of the third joint, and two at the end of this same terminal joint. Of these spines the four proximal ones are slender and a little delicate, but the fifth and terminal one is a strong curved claw more than twice as long as the others. The earlier mentioned fifth pair of legs is present as a little bud with two setae on the ventral side of the posterior corners of the genital segment.

Total length, 5 mm. Length of carapace, 3 mm. Breadth of carapace, 2.2 mm. Length of genital segment, 1.3 mm. Length of abdomen 0.8 mm.

Male: Contrary to that found in most species, the male is a little larger than the female. The carapace is ovate like that of the female but narrowed rather more anteriorly, and is one-third longer than wide. The median lobe is much longer than in the female; it reaches far behind the lateral lobes, and the latter are more inwardly curved and pointed than in the female. The male abdomen is two-segmented, comprising a short proximal segment and a distal one which is twice as long.

The second antennae have the short curved hook as found in many males, and are further furnished with an accessory spine in the form of a flat plate. The first maxillae are distinctly three-jointed, and the second maxilliped much larger than in the female.

Total length, 6 mm. Length of carapace, 3.5 mm. Width of carapace, 2.8 mm. Length of genital segment, 1 mm. Length of abdomen, 1 mm.

Remarks: the species is of medium size for a caligid, and is easy to recognise by its long mouth-cone, the three joints in the first maxillae, and the lone claw on the first pair of swimming legs.

Caligus sp.

In 1944, Dr. A. G. Nicholls published a paper on littoral Copepoda from South Australia. At the end of the paper there is included an illustration (fig. 28) of a male *Caligus.* No related text accompanies the figure, which clearly represents an undescribed species.

Genus **Lepeophtheirus** Nordmann, 1832

Lepeophtheirus elongatus sp. n.

(Figs. 116-123)

Locality, Host and Record of specimens: About 25 females, including the holotype, were found on the palate and tongue of a Whaler Shark (*Galeolamna greyi* Owen) at Rossiter Bay, Esperance, Western Australia, collected by G. P. Whitley, 25.1.1944.

Female: This is the usual large and stout type of copepod as found on sharks. The carapace is orbicular, being even a little wider than long. The frontal plates are narrow and not so well defined. The posterior sinuses also are narrow at their entrance, and they are inclined somewhat away from the median line. The median lobe is broad and squarish, cut nearly straight posteriorly, and not projecting beyond the lateral lobes. The last-named are narrow and curved towards the median lobe posteriorly. The grooves separating the areas of the carapace are well defined and strong in the posterior half beyond the " H "-shaped cross-bar of the main grooves. Anteriorly and in front of the cross-bars the bars on the carapace are weak and not well defined. The free segment is rather elongated, commencing at the carapace with a neck which widens out backwards to a pair of shoulders for the attachment of the fourth pair of limbs. The way in which the limb is jointed to the segment is rather characteristic, because a big triangular part is without cuticle, as shown in the figure; this enables the limb to be moved straight forward. The genital segment is nearly as long as the carapace, longer than wide posteriorly, and drawn out into two lateral lobes. The abdomen is built up of three segments and is very long—about the length of the carapace plus the free fourth segment. The first two segments are of equal length, the third is a little short one. The anal laminae are flattened and parallel, tipped with four setae and a short spine medially.

The first antenna has a globular basal joint with many thick sensory hairs at its margin; the second joint is delicate, nearly four times as long as wide, and tipped with a group of short setae. The second antenna is four-jointed, with first a narrow schlerite partly absorbed in the body. The joint following this is still coalesced with the body on its ventral side, and is furnished with a backwardly directed spine. The next two joints are free, with first a squarish third joint, followed by the fourth in the form of a long slender hook. The mouth-cone, with the mandibles, is short and delicate. The first maxilla is well developed, the basal joint coalesced with the body and provided with a curved, hook-shaped endopod and a small exopodal palp. The second maxilla is two-lobated—a basal joint partly coalesced with the body and furnished with a curved one-jointed hook, the endopod, and a two-jointed exopodal palp.

As shown by Heegaard, 1955 (pp. 47-48, fig. 10), in caligids, the dorsal grooves between the eucephalic and postcephalic areas become converted into internal ridges. A second transverse grooving with internal ridges is placed between the postcephalic area, and this carries the sternal furca. Normally the first ridging between the eucephalic and postcephalic areas does not carry any spines; it is not always even clearly visible. In the present species, however, the ridging is distinct, especially when seen from the ventral side, as it passes between the second pair of maxillipeds. On the ventral side it is furnished with a pair of slender spines, with their points

directed a little towards each other just in front of the outgrowth of the furca. The furca itself is fairly strong, with its two branches widely spread; near their base they are joined with a cross bridge. To the sides of the furca proper are small supporting spines, one at each side.

The first maxillipeds are of the normal slender type but three-jointed, with the " basal joint " divided into a shorter basal joint and a longer distal one. The third joint of the maxillipeds is tipped with two fingers of nearly the same length. Placed a little proximal to these two fingers there is a smaller accessory finger, but on the same joint. The second maxillipeds are of the normal two-jointed type in the form of a subchela and are of medium size and strength.

The first pair of swimming legs is well developed, with a clear coxa and basis, a two-jointed exopod and a vestigial single-jointed endopod. The coxa is plumpish, with an anterior spine and a posterior seta. The basis is much smaller and furnished with a strong exopod, of which the first joint is more than twice the length of the second and longer than the coxa and basis together. Near the base of the second joint of the exopod there is, anteriorly, a small spine. The distal joint of the exopod is provided with the usual three spines and three plumose setae, in between which is found a single, longer, slender, and sensitive plumose seta.

An extraordinary feature of this species is the vestigial bulb-shaped endopod, which in most species is represented only by a small spine or is entirely absent.

The second pair of legs is noticeable only by the toothed anterior ridge on the first endopodal joint and a fairly well-developed swimming membrane on the frontal margin of the exopod. The rami of the third legs are closed together. The exopod has a short basal joint with a strong curved claw used when crawling on the surface of the host fish and for penetrating beneath the scales from behind. The terminal joint is followed by an elongated second and third joint, of which the third joint is flattened. The endopod is short and strong, with the usual two joints. The fourth pair of legs is long and well developed, four-jointed and with five spines, of which three are terminal. Of the three terminal spines the most distal one is long, slender and hook-shaped, followed by two shorter, nearly straight, spines. The remaining two spines tip the second and third joints. A membraneous cushion of sensory function is placed on the lateral side of joints numbers three and four, backwards from the spines on the joints and reaching nearly to their bases. The leg itself is jointed to the free fourth thoracic segment with a sort of shoulder joint, as previously mentioned. No signs of a fifth or a sixth pair of legs are to be found on the genital segment.

Total length, 11 mm. Length of carapace, 3.4 mm. Width of carapace, 3.5 mm. Length of fourth segment, 1 mm. Length of genital segment, excluding lateral lobes, 2.5 mm. Length of abdomen, 4.3 mm.

Remarks: Outstanding characteristics of this species are the long three-segmented abdomen, the shape of the furca and the sub-furca; the endopod on the first pair of legs; the toothed ridge on the first endopodal joint on the second leg; and the fourth pair of legs with its shoulder attachment to the segment, its membraneous sensory cushion and very slender hook-shaped spine. Some of these characters suggest even a new subgenus.

Male: Unknown.

Lepeophtheirus molae sp. n.

(Figs. 124-134)

Locality, Host and Record of specimens: Nearly 100 females, 1 male and 1 juvenile, from which the holotype was selected, were found parasitic on a Sunfish (*Mola mola*) in Port Jackson, New South Wales, 13.12.1882. Australian Museum Reg. No. G. 5213. A further 11 females, also taken from *Mola mola* in Botany Bay, New South Wales, 8.12.1930. Australian Museum Reg. No. P. 9990.

Female: The carapace is orbicular, even a little wider than long; its lateral areas are wide, each nearly one-third of the entire width. The dimensions bring about an unusual shape in the longitudinal ridges running down through the carapace and dividing it into a medial part and two lateral lobes. Posteriorly, these ridges are free of the carapace and are produced backwards as two spines from the dorsal surface. This character is a most distinctive one, and not known in any other *Lepeophtheirus*. The posterior corners of the two lobes referred to, each have a smaller inner lobe towards the posterior sinus. The frontal plates are small and well fused with the carapace, less than half the width of the latter, and have a shallow central incision. The eyes are small and placed less than one-third the distance from the anterior margin. The median posterior lobe is the same length as the lateral lobes, and has rather squarish corners, making the posterior margin nearly straight.

The fourth or free segment is one-third the length of the genital segment and more than two-thirds of its width, and projects prominently on each side at the bases of the fourth legs. The genital segment is ovate, with an evenly-rounded outline and prominent posterior corners; the sixth pair of legs project as spines from its ventral side. A sixth segment is fused to the genital segment, and associated with it in fully mature specimens there can be seen a small vestigial fifth pair of legs. In young females examined (figs. 130, 134) the genital segment was not yet fused, and rudimentary legs were found on the fifth segment or first genital segment.

The abdomen is two-segmented, but the basal segment is small and may easily be overlooked; it is less than half the length of the second abdominal segment. In a young female examined (fig. 134) the abdomen was clearly three-segmented, but in the normal adult state two of these segments are found fused together. The anal laminae are of medium size and curved inwards towards each other, and each is furnished with the usual four setae.

The first antenna is delicate, with a long and slender second joint and only a few setae at its tip. The basal joint has a fringe of setae at its frontal margin. The second antenna is a strong hook-shaped organ of three joints—a short basal joint with an accessory spine, a median joint which is twice as long, and a long, slender and curved hook for the distal joint. The mouth-cone is rather short and diminutive compared with the size of the copepod. The first maxilla is prominent, the circular basal portion being three or four times the diameter of the curved terminal part, and furnished with a backwardly-pointing accessory spine. The second maxilla projects far beyond the tip of the mouth-tube. It is longer than the tube itself, strongly bifurcate, slightly curved, and as long as the rest of the maxilla. At the base of the maxilla is a small papilla—the rudimentary exopod, bearing a long seta. The first maxilliped is long, slender, two-jointed, and bifurcated at the tip, with the median claw much longer than the lateral one. On the lateral side of the second joint is placed a palpiform branch, around which is a leaf-shaped membrane (fig. 125). The second maxilliped is stout, the basal joint bearing a small protuberance on its anterior or median margin. The terminal claw is of about the same length as the basal joint, strongly hook-shaped and armed with an accessory spine on its ventral surface about one-third of the way from its base. The sternal furca is delicate, elongated, and with two long, bluntly-pointed branches.

The basal joint of the first swimming legs is armed with a hairy seta midway along its posterior margin and at the posterior tip with a small bulbous process, the last part of which is the vestigial endopod. The second pair of swimming legs is of the usual pattern, with membranes on the third and fourth spines of the distal joint. The third pair of swimming legs has a flattened hairy spine on the sympodial plate, just outside the exopod. The spine on the basal joint of the exopod is large, inwardly curved and sickle-like in form. The fourth swimming legs have a strong basal joint, followed by three shorter joints of which the two first are tipped with a small claw; the last joint is tipped with one short and two long claws, the latter being toothed on their inner margins.

The genital segment is a coalescence of two segments, as claimed earlier on the characters displayed by a young female. The larger legs were found on the sixth, and not on the fifth segment, as is usually the case. This sixth pair of legs is, in the adult female, shaped as two spines projecting posteriorly from the ventral side of the genital segment (figs. 124, 130). The spines are two-jointed, as there is still a suture to be seen near their tips. Near their base a transverse ridge is found, indicating where another joint is located. This shows that there were originally at least three joints, as was so much more clearly evident in the young female already discussed. The spines are further furnished with some vestigial setae. Also to the sides of them there is placed a small bud with two setae. These buds are not seen in all the specimens—only in some of the larger females. The buds are actually the rest of the fifth pair of legs which, because of the swelling of the genital segment, has been pushed behind the spiny sixth pair of legs.

Total length, 12 mm. Length of the carapace, 7 mm. Width of carapace, 8 mm. Length of genital segment, 2.5 mm. Length of abdomen, 1.3 mm.

Male: The carapace is similar to that of the female, but relatively much larger. The eyes are also more prominent. The fourth free segment is much narrower than in the female, almost square, and only a little wider than the genital segment that follows. This latter is clearly made up of two segments, and has the typical shape of a male genital segment. It is furnished with two pairs of spines of about equal size which represent the vestiges of the fifth and sixth pairs of legs, each shown to be three-jointed. The abdomen is clearly two-segmented.

The first maxilla is stout, and shorter than in the female. The second maxilliped is small but very stout, with a crest on the side of the clasping joint near the claw. The coxal plates of the third pair of legs are very large.

Total length, 5.5 mm. Length of carapace, 3.5 mm. Width of carapace, 4 mm. Length of fourth segment, 0.5 mm. Length of genital segment, 1 mm. Width of genital segment, 0.7 mm.

A single young specimen of the series examined was found to have a two-segmented genital segment and a three-segmented abdomen (fig. 134).

Remarks: This species has a strong resemblance to *Lepeophtheirus spinifer* Kirtisinghe (1937, p. 442), but a number of differences can be readily detected. The ridges of the carapace are not identical; the second joint of the first antenna is more slender in *L. molae*; the setae on the distal joint of the first pair of legs differ in number and shape; the third endopodal joints of the second pair of swimming legs differ, as also do the spines on the fourth pair; there is a difference in the size and shape of the sixth pair of legs, and also in several other points concerning size. Kirtisinghe's species from a *Chorinemus* was less than half the size of this species.

Another species, *L. insignis* Wilson 1908 (p. 444) was also found occurring on a Sun Fish, *Mola mola.* At first glance it appeared to be identical with the present species, but a further study revealed so many points of difference that it was decided to create a new species for the material before me. Only a direct study of Wilson's material can show whether this action can be justified. Among the differences can be mentioned the presence of a spine on the carapace of *L. molae*, the two-segmented abdomen, and the cresta on the first maxilliped which is not described by Wilson. Then there is the coxal spine on the third pair of legs, and the shape of the fifth and sixth pair of legs which are entirely different from Wilson's description. Finally, the genital segment of the male and its appendages are different from what is described by Wilson.

Family Euryphoridae

Caligulus gen. n.

Type species **C. longispinosus** sp. nov.

This new genus has all the characters of *Caligus*, with the addition that dorsal plates from the third thoracic segment entirely cover the fourth segment.

Caligulus longispinosus sp. n.

(Figs. 135-144)

Locality, Host and Record of specimens: One female, the holotype, and one male, the allotype, were found on the skin of *Euthynnus altitteratus* (Mackerel Tuna) at Howick Islands, North Queensland. Collected by A. G. Nicholls, 6.11.1948.

Female: This small species has a markedly elongated carapace, its length being about one-and-a-half times its greatest width, and with nearly parallel lateral margins. The frontal plates are wide and large, distinctly separated from the rest of the carapace by the anterior transverse ridge. The lunules are of medium size, circular, and project only a little in front of the anterior margin of the frontal plates. The lateral lobes are very narrow and the medial lobe very large. The latter occupies more than two-thirds of the entire width of the carapace, and extends far backwards to form a big dorsal plate which, through its transverse lunules, clearly shows it to have been originally paired. This medial dorsal plate extends backwards to entirely cover the fourth segment, and even slightly overlaps the genital segment. Because of this elongated plate the thoracic area appears to be nearly twice as long as the cephalic area. The posterior lunules of the carapace are shallow, pointing a little in a medial direction. The eyes are small and placed far anteriorly—in about the first third of the cephalic area. The genital segment is quadrangular, with an incision well posterior for the one-segmented abdomen, the latter furnished with an anal lamina of normal size.

The first antenna is small, with its basal joint furnished only with few and very short setae; the distal joint is short, club-shaped, and tipped with a few short setae. The second antenna is short, three-jointed, and placed well backwards behind the mouth-tube; the basal joint, coalesced with the carapace, is the largest, and is followed by a cylinder-shaped medial joint; the distal joint is nearly straight, ending in a small hook furnished with an accessory spine which is only small in the female, but in the male it is as large as the tip of the joint, giving it a bifurcated character. The first maxilla was found to be torn off in the female specimen, so it may possibly have been a strong hook embedded in the skin of the fish host, although it was not found strongly bent in the male. The second maxilla is short-jointed, with the free distal joint pointing directly backwards. The mouth-tube is broad but short, with rather short mandibles, and its base is a little in front of the second antenna. The first maxilliped is small and a little delicate; it has a short basal joint followed by two longer joints, of which the second

or the third has a small accessory palp medially. The same appendage is tipped with two fingers, of which the medial one is more than twice the length of the lateral one, and this is further two-jointed and strongly bent into a semi-circle. The second maxilliped is small and weak and three-jointed; first and second joints are of normal shape, and the third joint shaped into a claw furnished with an accessory spine. The sternal furca is short and wide, with its two branches shaped like a horse-shoe, and extended into two very blunt tips.

The first swimming leg is small, with the first joint very short, squarish, and dorsally extended into a small lobe above the following joint. Ventrally, a small spine is all that is left of the endopod. Of the two following exopodal joints, the first has a convex medial margin with a fringe of short setae, and a short spine dorso-laterally. The distal joint is tipped with three short claws, followed by a small sensory seta. The three feather-shaped spines on the medial margin of the same joint are furnished on their inner lateral parts with short spiny hairs which, for the rest of the seta, are followed by the normal hairs of a feather-like seta (fig. 141). The second swimming leg is short, with a very short coxal joint having one feather-like seta directed posteriorly. The basis is large, plump, squarish to elliptical in shape, and lacks setae. Both exopod and endopod are three-jointed. The first exopodal joint is as long as the two following ones together. It has a long feather-like seta on the medial border, and a long bent, concave spine at the latero-distal corner. The following joint is short, with one spine and one seta, and the terminal joint is furnished with five feather-like setae and three spines, the latter increasing in length from proximal to distal, the two most distal spines being half feather-shaped, with hairs on their medial sides. The most distal spine has, in addition, a membrane on its lateral margin. The endopod is of the usual three-jointed type, with one, two and six feather-like setae on the three joints—from proximal to distal. The second endopodal joint is further toothed on its lateral margin. The third leg has a very large elliptical sympodial plate which enables the limb to reach back to the genital segment. The claw on the basal joint of the exopod is nearly straight; the two branches of the limb are placed far apart, with the endopod a good distance behind the exopod. The fourth leg is three-jointed and slender with one spine on the second joint and three spines on the distal joint. With the exception of the first, these spines are very long and delicate, and partly curled in shape (fig. 144); they appear to be functionally useless. Unfortunately, the distal joint of the fourth legs was missing in the single male specimen, so that the description of this character can refer only to the single female, in which it is possibly partly misshapen. Normally, this distal joint must surely be long and delicate. No fifth or sixth pair of legs were found on the genital segment of the female. The egg-strings were long and slender—longer than the total length of the female.

Total length, 3.5 mm. Length of carapace, 2.5 mm. Width of carapace, 1.6 mm. Length of genital segment, 0.9 mm. Width of genital segment, 1 mm.

Male: The male is about the same size as the female, but has the frontal plates and lunules noticeably more prominent than in the female; the carapace also is a little larger and stouter. The genital segment is more rounded elliptically than in the female; its two lateral lobes are tipped with two small spines, each the vestigial part of the fifth pair of legs.

Of the appendages, the accessory spine on the distal second antennal joint is as large as the tip itself, making this bifurcate. The first maxilla is a stout hook attached to a small basal plate, which is coalesced with the carapace. The second maxilla is larger than in the female, but more straight. The second maxilliped is, unexpectedly, as weak in the male as in the female, but the sternal furca is much larger in the male, its two branches bifurcating directly outwards from its basal plate, with the gap between them increasing distally.

Total length, 3.2 mm. Length of carapace, 2.7 mm. Width of carapace, 1.8 mm. Length of genital segment, 0.6 mm. Width of genital segment, 0.8 mm.

Remarks: This small species can be recognised principally by its swimming legs and the accessory spine on the second antenna. The presence of dorsal plates on the carapace covering the fourth segment and overlapping the frontal margin of the genital segment is the character which establishes the new genus.

Genus **Tuxophorus** Wilson, 1908

Tuxophorus cervicornis sp. n.

(Figs. 145-150)

Locality, Host and Record of specimens: Four females, including the holotype, were found on the mouth, and probably the gills, of a *Scomberomorus commerson;* the exact location on the fish cannot be stated with any certainty. The species was found in company with *Caligus maculatus* Heegaard, *C. circularis* Heegaard, and *Paracycnus lobosus* Heegaard, but no further details accompanied the specimens. The fish host was caught in Torres Strait, North Queensland, by A. G. Nicholls, 23.11.1948. A similar host fish infested with one female of the same copepod was caught by A. G. Nicholls, 6.11.1948, eight miles south of Cape Direction North Queensland.

Female: The carapace is ovate, nearly orbicular, a little longer than wide, and about half the entire length of the body. The frontal plates are prominent and furnished with small hemispherical lunules. The lunules are widely separated and project a little in front of the anterior margin of the frontal plates. Between the lunules a narrow membrane is found in advance of the frontal plates. The posterior sinuses are narrow and shallow, and nearly closed at the opening from the corners of the medial lobe and the two lateral lobes. The medial lobe takes up about half of the entire width of the lateral lobes, and projects only a trifle beyond them. It is quite squarely truncated posteriorly, with prominent corners towards the lunules, the cephalic area being nearly twice as long as the thoracic area. The lateral lobes are broad and curved inwards towards the medial line at the posterior tips. The eyes are very small, but with prominent lenses, and are placed in the middle of the cephalic area between the encephalic area and the post-cephalic area; the two latter are of about equal size.

The free segment is large and squarish in shape, and nearly twice as wide as long. It is covered with a pair of broad wings, differing from other previously known species of *Tuxophorus* in that they extend as much forwards as backwards; they extend outwards to a level with the lateral margins of the genital segment, and far enough backwards to cover over the base of the same. The frontal margins of these wings or aleae are curved and inclined slightly forwards; in younger individuals, especially, they reach and overlap the posterior margin of the carapace. In older specimens the fourth segments appear to grow a neck, which places the frontal margins of the wings a little further backwards so that they do not reach the carapace. This older stage of development is shown in the figure. The wings bear a remote resemblance to those of a moth or a butterfly.

The genital segment is quadrangular and about two-thirds the width of the carapace. At its postero-lateral corner the fifth pair of legs is shaped in large branched horny spines pointing postero-laterally, appearing like the antlers of a deer. The abdomen is elongated and two-segmented, like that of *T. caligodes* Wilson (see Heegaard, 1955); the segmentation is not very clearly defined, and can easily be overlooked. The anal laminae are long and pointed and without setae, like those of *T. cybii* Nunes-Ruivo.

Egg-tubes are of about medium length, each containing 60 to 100 eggs. The first antenna is, as usual, two-jointed, the basal joint being longer than the distal one and heavily clothed with short plumose setae; the distal joint is tipped wiih only a few setae. The second antenna is three-jointed. The first joint, which is coalesced with the carapace, has a posteriorly-pointing spine. The following two-joints are free, the distal one being formed into a strong hook. The maxillae are small and two-jointed, the first joints being coalesced with the body. The second joints are formed posteriorly into pointed hooks. No palp could be seen on either of the maxillae. The mouth-cone is rather short and blunt, with a short pair of mandibles.

The first pair of maxillipeds is long and slender, as in *Caligus* but, unlike *Caligus*, the distal joint is divided into two joints, with the partition just behind the little palp on the lateral margin. The distal joint is tipped with two fingers, of which the medial one is twice as long as the other; both fingers are somewhat curved. The second maxilliped is also unusual in that it possesses an extra joint. The limb is relatively small and weak, with a basal joint of normal shape and size, followed by two joints instead of one—first a short joint and then a large, curved, terminal claw. The sternal furca is strongly developed, with a large massive basal plate from which extend the two posteriorly-pointing horns. This is the first of the known species of *Tuxophorus* with a sternal furca of relatively simple build; even the closely-related *T. cybii* has an extra spine on the furcal branches. It shows that the furca does not have to be of a complicated form in the genus *Tuxophorus*. Among the known species of *Tuxophorus*, the present one comes closest in several points to the genus *Caligus*.

The first pair of swimming legs is three-jointed. The first joint is rectangular, with a lateral swelling and a small palp at the medial-distal corner, representing the vestigial endopod. The second joint is elongated, fringed with setae at its medial margin, and has a small, short spine at the latero-distal corner. The third and last joint is short, and tipped with the usual three spines, which are embryonic; the presence of small embryonic hairs shows that these have been derived from a feather seta. The three feather setae on the medial margin of the same joint are exceptionally short, especially the most distal one. The second leg has a normal stem with a short coxa furnished with one seta, and followed by the basis, without any setae. The endopod is three-jointed, with one seta on the first joint, two on the second, and six setae on the third joint. Further, the first and second joints of the endopod are fringed with hairs on their lateral margins. The exopod is exceptional in that it is four-jointed; the length of the first joint is equal to that of the three following ones. The first three joints are each furnished with a spine and a long swimming seta. The fourth joint has a spine and five setae; the seta nearest to the spine is half spine, half seta. The appendages of the genital segment are only the branched

spines at the posterior distal corner of the segment. From this the impression might be gained that the basal spine is one branch of the limb and the large distal spine with two side spines branching from it represents the other limb-branch. It was because these spines on the genital segment were so very characteristic that the species was given its specific name, *cervicornis*.

Male: Unknown.

Genus **Gloiopotes** Steenstrup and Lütken, 1861

Gloiopotes longicaudatus (Marukawa)

(Figs. 151-153)

Caligus longicaudatus Marukawa, 1925, p. 1243, fig. 2396; 1947, p. 927, fig. 2654.

Gloiopotes sp., Yamaguti, 1936, pt. 3, p. 4, pl. 2, fig. 20; pl. 3, figs. 21-35.

Gloiopotes longicaudatus, Shiino, 1954, 4, p. 273, figs. 1-2.

According to Shiino (1954) this species was first described by Marukawa in 1925 as *Caligus longicaudatus*, but its record in an Encyclopaedia of the Fauna of Japan was overlooked by Yamaguti (1936), who described further Japanese material of the same species under the name *Gloiopotes* sp., because of a resemblance to both *G. ornatus* Wilson (1905) and *G. constatus* Wilson (1919). Besides the listing of some minor variations from these two species, Yamaguti describes as the main difference the fringes of hairs on the carapace. The differences, however, are numerous enough for the full establishment of a species. The same conclusion was reached by Shiino (1954), who returned it to Marukawa's specific name, but placed this in the genus *Gloiopotes*, thus agreeing with Yamaguti. He further redescribed the species. These three authors were all Japanese and had their material from the Pacific coast of Japan and the Mariana Islands. The hosts were *Tetrapterus mitsukurii* Jordan and Snyder, *Parathynnus sibi* (Temminck and Schlegel), *Xiphias gladius* L., and an unknown host collected at the Palao Islands.

Locality, Host and Record of specimens: Both males and females of this copepod are represented in the material before me, all belonging to the Australian Museum in Sydney. First there are 24 specimens from the skin near the anal fin of a Striped Marlin (*Marlina zelandica*) at Bateman's Bay, New South Wales, 11.3.1936 (Reg. No. P. 10750). A second capture of 23 specimens from the gill-opening of a Black Marlin Swordfish (*Istiompax australis*) caught off Port Jackson, New South Wales, 12.3.1948; collected by Mr. Holliday, a visitor from the Peabody Museum, U.S.A. (Reg. No. P. 11903). A third series of 8 specimens are from another Black Marlin Swordfish caught off Broughton Island, Port Stephens, New South Wales (Reg. No. P. 11806). From these and earlier records it can be assumed that the species occurs in the Western Pacific from Japan to Australia and probably eastwards from there to New Zealand, whence it has not yet been recorded. Its range also very likely extends farther eastwards into the island waters of Polynesia. The hosts are the larger species of the scomber or mackerel family, belonging to the travelling pelagic fishes, and from this it is reasonable to assume that the parasite has a vast distribution within the Pacific Ocean.

The figures of the species printed in this paper show some points varying both from Shiino's description and also from Yamaguti's (1936) description of *Gloiopotes* sp. While the publication of these figures is justified, I have no doubt that all three of us are dealing with the same species. Marukawa's 1925 description of the species has not been accessible to me, and I know it only through Shiino.

In the figures of both Yamaguti and Shiino the carapace is shown to be a little longer than wide, but the present material shows it to be proportionately wider in older and larger specimens. On each half of the genital segment I have found three large spines placed dorsally in a distinct line and one spine placed laterally from this line. Both Yamaguti and Shiino recorded the presence of four similarly-situated spines, but in a different arrangement. The abdomen is clearly two-segmented, and the anal laminae consists of two joints. Of the latter the basal joint is short and wide, while the distal joint is long and slender and tipped with two or three very short and reduced setae. The first antenna is three-jointed as described by Shiino, with the medial joint carrying no setae. The second antenna is four-jointed, with the two first joints coalesced with the body. The fifth thoracic leg, shaped in the form of a postero-lateral spine from the genital segment, has a variable number of teeth or smaller spines. In addition a hairy, bulbous spine on a stalk is found on its medial margin towards the tip, which is clearly of a sensory nature (fig. 151, pl. 5).

Genus **Alebion** Kröyer, 1863

Alebion carchariae Kröyer

Alebion carchariae Kröyer, 1863, p. 165, pl. xii, fig. 1, a-l; *Id.*, Bassett-Smith, 1898, p. 366, pl. xii, fig. 1, a-d; *Id.*, Heegaard, 1955, p. 49, figs. 12-18.

Locality, Host and Record of specimens: Four females from pectoral fin of female Tiger Shark (*Galeocerdo cuvier*); Peron Peninsula, Shark Bay, Western Australia. Collected by G. P. Whitley, 3.9.1944.

Remarks: Kröyer had a single female of this species, without egg-strings, which caused him to determine it as a male. It was found on a large shark in the Atlantic Ocean. Thirty-five years later it was found for a second time by Bassett-Smith, who recorded two females on the pectoral fin of a small shark caught at Aden. Then a lapse of more than fifty years occurred before a single female from West Africa was presented to the author and redescribed (Heegaard, 1955). These were followed by the latest material from Shark Bay, Western Australia. The male of the species is still unknown. As the Tiger Shark host is widely spread in the tropics and the copepod species now has been recorded first from the Atlantic and twice since from the Indian Ocean, it can be expected to be found occurring much more commonly than its present records suggest.

Family Pandaridae

Genus **Perissopus** Steenstrup and Lütken, 1861

Perissopus serratus sp. n.

(Figs. 154-161)

Locality, Host and Record of specimens: Two females, including the holotype, from nostrils of a shark (species unknown); Flinders Island, North Queensland. Collected by A. G. Nicholls, 5.11.1948.

This new species is closely related to *Perissopus dentatus* Stp. and Ltk. and *P. communis* Rathbun, both from the Atlantic Ocean. The present record represents the first recognition of the genus from the Pacific Ocean.

The new species is distinguished from the two other known species of the genus by its proportionately longer and narrower body, even longer than in *P. communis*. The postero-lateral angles of the cephalothorax are also comparatively much longer, and point backwards like a long curved sabre-shaped alea on each side. Other differences are the strong dentation of the free margins of all the dorsal plates on the thorax, and the shape of the genital segment and anal laminae. Again, the second antenna, thoracic appendages and swimming feet all differ from those of the two other species.

Female: The body is elongate, its length being about twice the width, but the carapace is wider than long, its medial part running out laterally in two long aleae, semi-elliptical in shape. The frontal plates are wide and prominent, placed like a bar across the front of the animal and drawn out in two rounded, free lappets partly covering the first antennae. Anteriorly there is a semi-lunular incision in the frontal plates. The lateral lobes of the carapace are narrow but projecting far backwards and drawing the carapace out into a lobe-like process on each side, making the posterior margin of the carapace strongly concave. This feature is much more prominent than in any of the other previously known species of the genus. Anteriorly on the carapace a line of three small eyes is found, the middle one a little smaller and a little posterior to the lateral ones. These eyes are not very distinctly seen in the adult female, and can be easily overlooked. The visible part of the dorsal plates of the second thoracic segment somewhat resemble in shape the same plates in *P. communis*, but they point more to the rear and are not inclined to the sides as in that species. The same plates are smaller and more elliptical than in *P. dentatus*. In general it can be said that all the dorsal plates are strongly serrated along their free margins—much more so than in the other known species. A wide space between the bases of the plates of the second segment and behind the posterior margin of the carapace is left uncovered, or has a narrow central plate which, at the medial line, runs backwards into a tip. The distance between the two plates of this segment is larger than in the other known species of the genus, and thus leaves a very broad but short open part. The dorsal plates of the third thoracic segment are wider but not so long as the first pair, and are semi-circular in outline. They are placed nearly horizontally or only slightly obliquely, with their tips meeting in the medial line. Their free posterior margins have short and sharp teeth.

The third pair of dorsal plates belonging to the fourth thoracic segment are considerably enlarged, circular, and extend across the entire width of the body. Their bases are covered by the posterior part of the second pair of plates, and their posterior margins are serrated and, in turn, reach for some distance over the genital segment. The genital segment is larger in size than the carapace and evenly-rounded anteriorly. Its lateral margins are convex, and its posterior margin is cut obliquely on each side with, at each posterior corner, a sharp and pointed spine curved towards the medial line. There is also a wide and deep median sinus on the posterior margin, and between the sinus and the corner spine on each side is a double or S-shaped curve, sweeping backwards at the side of the sinus into a dentated lobe that is turned forwards close to the spine.

The abdomen is small and plump, a little longer than wide, double barrel-shaped and one-segmented; it is entirely concealed beneath the genital segment. The anal laminae, also covered by the genital segment, are short, triangular and armed with minute and irregular teeth. The egg-strings are long, with large flattened eggs. They extend far behind the body and are about equal to it in length.

The first antenna is small and two-jointed. The basal joint is wider and longer than the terminal one, and its tip reaches beyond the margin of the frontal plate. Both joints are armed with thick setae. The second antenna is long, slender and four-jointed; at its basal joint a small adhesion pad is found. The third and fourth joints are formed into a hook shape, the terminal joint being strongly toothed at its medial concave margin (see figure). Behind the second antenna there is an elliptical adhesion pad of which the longitudinal axis inclines outwards and forwards at an angle of 45° to the body axis. This adhesion pad must, from its position, be the first maxilla. Enlarging on this question, it is worthy to note that, in all species of the genus *Perissopus*, the adhesion pads are placed on the basal joint of the appendage, and thus support the claim that they are the remnants of the basal joints of the first maxillae. The mouth-tube is very long, as commonly found in the Pandaridae. The mandibles are of the usual shape, but at their basal part outside the mouth-tube they are armoured with a narrow half-moon-shaped adhesion pad. The second maxilla is lammelar, and tipped on each side with a long and narrow spine placed close up to the mouth-tube.

The first maxilliped is of the usual pattern, but small and two-jointed. The terminal claws are rather stout, the external one considerably longer than the internal; on the side of the external one there is found a small accessory claw. The second maxilliped has a basal joint which is very fleshy and swollen. On the lateral side of the distal part of this joint is a large kidney-shaped adhesion pad. Wilson (1907) describes this adhesion pad in *P. communis* as representing the terminal joint, but this is contrary to the placement of all other adhesion pads, which are always found on the basal joint. In the present species it is seen that the adhesion pad is not the end of the limb, for on its posterior margin is placed a small vestigial joint with a small claw. These and the adhesion pad are pressed up against the large and fleshy basal joint and are certainly functionless, for they are far too weak. For clarity in illustration, this part is shown in the figure as removed from its natural position close to the large first joint, where it was difficult to see.

Each of the swimming legs consists of a smaller or larger plate-shaped basal joint which increases rapidly in size from front to rear, the basal joints of the fourth pair being many times the size of the first. The legs are biramous, with each ramus of the two first pairs distinctly two-jointed. The third and fourth pairs have only a two-jointed endopod, but the exopod is wholly fused into a single joint. There is a stout spine on the first exopodal joint of the first and second pairs, and three smaller spines on the second exopodal joint. The endopods are two-jointed and without spines or setae. In Pe_3 and Pe_4 the exopod is tipped with the three spines from the distal joint, but the stout spine on the proximal joint is missing, as this joint is coalesced with the following one. The endopod is two-jointed and without spines on Pe_3. In Pe_4 the one-jointed exopod has four small spines, the endopod one small bud on the first joint, and two on the second and distal joints.

Total length, 3.4 mm. Length of carapace, 1.3 mm. Width of carapace, 1.8 mm. Length of genital segment, 1.9 mm. Width of same, 1.9 mm.

Remarks: This is the smallest of the three known species of the genus, and the first from the Pacific region. It is also interesting in the shape of its second antennae, with their dentated tips, but more especially in the second maxillipeds, where a small vestigial terminal joint with a claw was found attached to the adhesion pad which, from its position, supports the evidence of a constant placement on the basal joint.

Genus **Echthrogaleus** Steenstrup and Lütken, 1861

Echthrogaleus coleoptratus (Guerin)

Dinematura coleoptrata Guerin, 1837, pl. 35, fig. 6.

Dinematura alata Guerin, 1837, pl. 35, fig. 7.

Echthrogaleus coleoptratus, Steenstrup and Lütken, 1861, p. 380, pl. 8, fig. 15; *Id.*, Wilson, 1907, p. 367, pl. 19, figs. 40-50.

Locality, Host and Record of specimens: About 25 females were found parasitic on a Blue Shark (*Prionace glauca*), caught off Cape Catastrophe, South Australia. Australian Museum Reg. No. E. 6793.

Remarks: The species is a fairly common parasite on various kinds of sharks. It has previously been collected in the Atlantic Ocean, Indian Ocean, south of Africa, and Japanese seas. The present new record from South Australian waters provides a natural link between south of Africa, Japan, and the Mariana Islands.

Genus **Dinematura** Burmeister, 1833

Dinematura producta (O. F. Müller)

Caligus productus O. F. Müller, 1785, p. 132, pl. 21, figs. 3-4.

Dinemoura producta, Latreille, 1829, p. 197.

Dinematura producta, Burmeister, 1833, p. 284.

Pandarus lamnae Johnston, 1835, p. 203, fig. 22.

Nogagus productus, Gerstaecker, 1853, p. 63, pl. 4, figs. 1-10.

Dinematura producta, Steenstrup and Lütken, 1861, pp. 371-374, pl. 7, fig. 13; *Id.*, Wilson, 1907, p. 380, pl. 13.

Locality, Host and Record of specimens: 12 females from the skin of a Basking Shark (*Cetorhinus maximus*). Locality unknown. Australian Museum Reg. No. P. 13225.

Remarks: The species has been recorded as a parasite on sharks from both sides of the North Atlantic. The following species in this record (*D. latifolia*) is a closely related copepod with a known cosmopolitan distribution, and this indicates that *D. producta* will later prove to be similarly dispersed wherever it finds shark hosts. Although without locality data, the present series of *D. producta* is assumed to have been collected in Australian waters.

Dinematura latifolia Steenstrup and Lütken

Dinematura latifolia Steenstrup and Lütken, 1861, p. 378, pl. 8, fig. 16; *Id.*, Wilson, 1907, p. 383, pl. 24, 25; *Id.*, Shiino, 1954, p. 308, figs. 9-10.

Locality, Host and Record of specimens: Four females found on a Blue Pointer Shark (*Isuropsis mako*) at Port Hacking, New South Wales, 12.5.1943. Australian Museum Reg. No. P. 13223.

Remarks: The species appears to be fairly common as a parasite of large sharks along the North Atlantic coasts of America and Europe. It is also found in the Mediterranean, south of Africa, Japan, and there is one record from the Pacific coast of the United States. Judging from the distribution of the species, it can be assumed that it has a cosmopolitan distribution, into which the present Australian record fits very well.

Genus **Pandarus** Leach, 1816

Pandarus bicolor Leach

Pandarus bicolor Leach, 1816, p. 405, pl. 20, 2 figs.

Pandarus boscii Leach, 1816, p. 406, pl. 20, 10 figs.

Caligus bicolor, Lamarck, 1818, p. 142.

Pandarus fissifrons H. Milne-Edw., 1840, p. 470.

Pandarus bicolor, Wilson, 1907, p. 400, pl. 27.

Locality, Host and Record of specimens: Four specimens found parasitic on a Blue Pointer Shark (*Isuropsis mako*) at Port Hacking, New South Wales, 12.5.1943; Australian Museum collection. About 25 specimens from skin of a shark captured at Lord Howe Island,

east of New South Wales; Australian Museum Reg. No. P. 6137. Four females from a shark captured at Marouard Island, east coast of Tasmania, 2.4.1911; Australian Museum Reg. No. E. 6791. Five specimens from a shark captured outside Oyster Bay, Tasmania, 15.7.1909; Aust. Museum Reg. No. E. 6795. Three specimens from Port Jackson, New South Wales; Australian Museum Reg. No. G. 5215.

Remarks: This copepod is recorded from European waters, East America and West Africa. The present additional records from Australian seas prove the species to be much more abundant than was formerly believed. There is every indication that it will later be found to have a cosmopolitan distribution.

Genus **Nesippus** Heller, 1865

Nesippus australis sp. n.

(Figs. 162-172)

Locality, Host and Record of specimens: Three females, including the holotype, were found, together with two females of *Perissopus serratus* Heegaard, on the mouth and nostrils of a shark at Flinders Islands, North Queensland. Collected by A. G. Nicholls, 3.11.1948.

Although this new species is closely related to *Nesippus alatus* Wilson, as well as to *N. orientalis* Heller, the characters separating the three are well marked and leave no doubt that they are all distinct. Well marked differentiating characters are found in the plates on the fourth segment, the genital segment, and several parts of the appendages. The species, *N. alatus*, as far as is known, occurs only in the Atlantic, and the present new species is from the Pacific coast of Australia.

Female: The carapace is nearly circular and a little transversely elliptical—width 2 mm., length 1.3 mm. The frontal plates are of the typical shape among species of *Nesippus* with an orbicular carapace, being rather narrow in the middle anteriorly, then widening laterally into two lamellar lobes which partly cover the first free segment of the first antenna. In the middle between the two frontal plates is an incision at the point where the larval filament is placed. The posterior lunules are deep, and curved in a semi-circle so that, at the apex, they point nearly horizontally towards the median line. The lateral areas of the carapace are semi-circular, leaving about half the width of the carapace for the medial lobe. The cephalic area is small, and the thoracic area much larger and nearly square. The eyes are distinctly tripartite but small, appearing as three separate circular lenses arranged in a triangle in the centre of the posterior part of the cephalic area. The second and third thoracic segments are fused together and carry a rectangular lobe or plate on each side, which extends obliquely backwards nearly to the tips of the posterior lobes of the carapace. The posterior part of the third thoracic segment is in line with the anterior neck of the fourth segment, in front of the genital segment. This fourth segment is free and considerably narrowed anteriorly, but with strong convex lateral margins, each ending in a small lobe posteriorly and with a wide but shallow incision between these lobes. The same segment is covered with a pair of fused dorsal plates, each of them being nearly circular in outline, with the shallow incision between in strong contrast to the angular pair of plates on both the second and third segments. The fourth segment is, however much narrower than the following genital segment, over the anterior margin of which the plates of the fourth segment extend for nearly one-third of their length. The genital segment is elliptical or slightly ovate, with an evenly-rounded margin except for the postero-lateral corners, where there is a distinct incision, giving a median lobe to the posterior margin of the otherwise somewhat ovate-shaped segment. The length of the genital segment is about one-and-a-half times its greatest width, which is found a little behind the middle of its length. The abdomen is invisible in dorsal view, but the two large anal laminae project for nearly their entire length behind the posterior margin of the genital segment. Each lamina is a little wider than long, and is armed with four slender plumose setae. Seen ventrally, the abdomen is small and strongly triangular in shape—more so than in any of the other known species of the genus. It is attached for about its entire length in front of the posterior margin of the genital segment, so as to be concealed by this from a dorsal view. To the apex of the triangle formed by the abdomen is added a narrow neck where the abdomen joins the genital segment, while the broad base which declines a little to the sides is at the posterior margin where the anal laminae are attached. The egg-strings are almost pure white, long and slender, and with small thin eggs in the strings.

The first antenna has two free joints, and what seems to be a third one coalesced with the body. Of the two free joints the first is the larger, and is about twice as long as the following one. The former is cylinder-shaped and armoured at its distal end with several stout sensory hairs. The distal joint is conical, with the apex stuck into the previous joint, and armoured with setae at its tip. The second antenna is large, four-jointed, and with a long and stout terminal

claw. The first joint is squarish, with a backwardly-pointing spine, and laterally a circular adhesion pad is present. The second joint is conical towards the third joint, which is a short squarish cylinder tipped with the terminal hook-shaped joint, the latter being furnished on its median concave margin with a small accessory hook. The first maxilla is placed close up behind the first antenna, but a little to the side of the base of that appendage, and close to the margin of the carapace. It is one-jointed, and its tip is shaped into an elliptical to triangular adhesion pad. This pad is built up of longitudinal running furrows, and from its placement on the distal part of the joint, it appears most likely to represent the first maxilla in the caligids. In a proximal position to the pad the rest of the joint is to be found partly coalesced with the ventral side of the body. The second maxilla is placed close to the mouth-tube. It is of the normal Pandarin type, consisting of a basal knob furnished with two palps. The exopodal palp is only a backwardly-pointing spine, but the endopod consists of two small joints without any setae or spines.

The maxillipeds are rather complicated organs. The first of them is basally a very movable joint to the carapace, not covered with thick cuticle, which gives to the appendage the possibility of circular movements. After the basal joint there follow two joints proper, the first of which is the larger. The second joint is furnished with two branches, the larger one with three spiny ridges running in an open spiral up along the side (see figure). This same branch is further tipped with a small bulb, with an incision in its tip. The smaller branch of the second joint also has two parts—a thin slender hairy palp which, like the larger one, is tipped with a bulb featuring the same type of incision. It is not known how the bulbous organs function, but there is no doubt that they are of a sensory nature, and possibly the three rows of teeth on the basal part of one of the branches has a rasping function. The basal part of the second maxilliped is coalesced with the body, running as a strong ridge from front to rear nearly parallel with the median line. At the anterior base of this ridge is an adhesion pad carried on a sort of stalk springing from the appendage. After this coalesced part, there follows a free, swollen fleshy section carrying at its end a larger bud-shaped adhesion pad, somewhat like a mushroom in shape, the free fleshy joint being the stalk. From the fleshy joint underneath the adhesion pad there extends a small free joint tipped with a flat hook-shaped claw (see figures for further details).

The four pairs of swimming legs are all biramous. The rami of the first three pairs are two-jointed, and those of the fourth pair one-jointed. Further, the basal plate in the first and the fourth pairs is one-jointed, but in the second and third pairs a clear suture is to be seen dividing the plate into a coxa and a basis. The first swimming leg is the smallest, having a small rectangular basal plate, and two rami and a seta on its margin. The first exopodal joint has a single plumose seta, but like all the other setae, this is plumpish, weak and with very thin and few hairs. The second exopodal joint has a fringe of the same vestigial setae, and the two-jointed endopod has setae only on its distal joint. The second swimming leg has both a coxal and a basal part. The endopod is two jointed, with one seta on the first joint and a fringe of setae on the second joint. The exopod is also two-jointed, but the main part of the basal joint is transformed into a thin adhesion pad carrying only a single reduced seta. On the second exopodal joint there is also an adhesion pad, but much smaller in size, occupying only the lateral margin of the joint, which for the rest is tipped with the reduced type of setae. A reason for the poor development of the setae is that the function of the limbs has been changed partly into adhesion pads, with the help of which the copepod is able to skid around on the surface of the host. The third swimming leg is like the second except that the adhesion pad is here found only on the lateral margin of the second exopodal joint, and is very diminutive. The fourth swimming leg is small, but not as small as the first one. It has an undivided basal plate and both exopod and endopod are only one-jointed, but larger than the joints on the other legs, and probably act as support to propel the parasite forward when it is creeping on the surface of the host.

Total length, 3.8 mm. Length of carapace, including second and third segment, 1.9 mm. Width of carapace, 2 mm. Length of plates on fourth segment, 0.3 mm. Width of same, 0.6 mm. Length of genital segment, 1.8 mm. Width of genital segment, 1.2 mm.

Nesippus incisus sp. n.

(Figs. 173-181)

Locality, Host and Record of specimens: 20 females, including the holotype, found on a Gummy Shark (*Mustelus antarcticus*) from New South Wales waters. Australian Museum Reg. No. P. 13230.

In its general habits this species is very much like the previously described *Nesippus australis*. However, the aleae on the second thoracic segment are narrower; the aleae on the fourth segment are much larger, considerably overlapping the genital segment, and with a deep incision between the alea; the posterior median lobe of the genital segment is larger, and thus covers the entire abdomen and the basal half of the anal laminae. Several differences are also found in the appendages, which clearly establish the species as new.

Female: The carapace is strongly transversely elliptical, being 2.6 mm. in width and 1.5 mm. in length. The frontal plates are not so narrow in front as in *N. australis*, but more even in width. The free lateral lobe covering over the first antenna is also larger in *N. incisus* than in *N. australis*. The frontal plates are, together with the anterior and free margin of the cephalic area, projecting in a half circle from the anterior margin, deeply incised at the centre. The posterior lobes are short and only a little overlapping the lateral lobes of the second and the third segments. The cephalic area is small and narrow posteriorly, where the eyes are placed. The latter are of the usual tripartite type, with three separate circular lenses arranged in a triangle. Anteriorly, the cephalic area widens out, having its greatest width where it meets with the frontal plates. The thoracic area of the carapace is quadrilateral and nearly twice as large as the cephalic area. The lateral areas are semi-circular, and on their free margins anteriorly each begins with a small semi-circular lobe where the first maxilla is placed. This character is typical, and one not found in any hitherto known species. Along each free margin of the lateral areas of the carapace is found a thin adhesion membrane which commences anteriorly behind the small, semi-circular lateral lobe. The same membrane is also continued around the lateral area on the lateral side of the posterior lunules, where this side is made up of the lateral area of the carapace. The second and third thoracic segments are fused together, and carry a single rectangular lobe or plate on each side. In the young female (fig. 173B) the distinction between the second and third segments can still be seen, showing that the lateral plates belong to the second segment. From the third segment it can be seen how the basal plates of the limbs of that segment are placed as a second pair of wings. In their outline they follow behind the marginal contours of the lateral plates of the second segment, which extends obliquely backwards to the posterior tip of the lateral lobes of the carapace. By this means a complete circle is formed by the outer margins of the frontal plates, lateral areas of the carapace, posterior margins of the lateral plates of the second segment, and the basal plate of the third pair of thoracic limbs. The fourth segment is free and, anteriorly towards the third segment, begins with a narrow neck. The rest of the dorsal side of the segment is covered with a pair of large plates. In the anterior part these two plates touch each other and have grown together, but the slit between them becomes widened posteriorly, so that they far overlap the anterior part of the following genital segment as two large rounded lobes.

The genital segment is elliptical or slightly ovate, but with a distinct posterior lobe adding to its posterior margin. There is a strong incision in the margin on both sides where the lobe meets the margin of the rest of the genital segment. The same kind of posterior lobe is found also in *N. australis*, but is much larger in the present species, as it covers not only the abdomen, but also half of the anal laminae where they extend from the abdomen. Seen ventrally, the abdomen is small and triangular in shape and attached to the genital segment just in front of the posterior lobe of this segment. The apex of the triangle is directed forwards at its attachment to the genital segment. The anal laminae are shorter and more rounded than in *N. australis*, and each is furnished with the usual four plumose setae, plus a small lateral spine.

The egg-strings are of the usual shape found in *Nesippus*—long and thin, with many strongly compressed eggs in the string.

The first antenna has a short basal joint partly coalesced with the body, followed by two entirely free joints. The first of the free joints is long, cylinder-shaped, and with several plumose sensory setae at its tip. The terminal joint is much smaller, and extends from a little behind the tip of the large previous joint. It is conical in shape, with the apex of the cone at the point of union with the second joint. This same terminal joint is furnished with a few setae at its tip. The second antenna consists of four to six joints; the variation in number is caused by the three most distal joints forming the hook in older females being only a single joint in younger examples. The typical hook, consisting of two or three joints, is shown in the figure. The basal antennal joint is short, and is furnished on its side with a circular adhesion pad. The second joint is the largest, and is followed by a more quadratic joint which precedes the hook proper. In cases where the hook consists of three joints, as in the figure, the middle joint of the three is furnished on its concave side, half-way along its length, with a little bulb, and at its distal end, on the same concave side, there is found a delicate accessory spine.

The first maxilla consists mainly of a round adhesion pad. This is placed behind the first antenna on the anterior little lobe of the lateral margin of the lateral areas of the carapace. The second maxilla is close to the mouth-tube, and consists of a bulb with a single conical spine. The mouth-tube itself is shorter than in *N. australis*, but otherwise of the normal shape, and encloses the mandibles. The first maxilliped is three-jointed, as in *N. australis*. As in that species, the third joint is furnished with longitudinal ridges and on its tip a small bulb is present. A hairy palp or a plumose seta is also placed at the base of this same ridged joint. Again, as in *N. australis*, the whole appendage is attached to the body by a short stalk, giving it great mobility. The second maxilliped has its long stem coalesced with the body, and extending from the anterior end is an elliptical adhesion pad. The free end carrying the large adhesion pad is fleshy and bulbous, but not as fleshy as in *N. australis*. The short free segment furnished with the flattened curved claw extends laterally from the joint, underneath the pad.

The four pairs of swimming legs are all biramose, the rami of the first three pairs two-jointed and those of the fourth pair one-jointed. The first three pairs all have a bulb extending from the basal plate, lateral to the exopod. This bulb is clearly sensory on the second and third pairs of swimming legs but not on the first pair; on the fourth pair the bulb is replaced by a seta. Additional smaller adhesion pads are found on the lateral margin of the first exopodal joint of the second pair of swimming legs, and on both the first and second exopodal joints of the third pair of swimming legs. The first pair of swimming legs has a seta on the basal plate in a medial position to the two rami. Of the latter, the first endopodal joint is naked, while the second is furnished with three plumose setae and lined with hairs on its lateral margin. The first exopodal joint is the larger and has one seta; the second and shorter exopodal joint has several setae. The second swimming legs have the typical spiny sensory bulb or pad on the basal plate, lateral to the exopod. The latter is two-jointed, with only a tiny spine on the first joint, but it has a relatively large adhesion pad on the basal joint. The second joint is furnished with several plumose setae. The first endopodal joint has one plumose seta, and the second seven plumose setae. The third swimming legs are built like the second pair, being only a little larger in the basal plate. The sensory bulb is placed in the same position on the limb, but this is also a little larger. Both the first and second exopodal joints are furnished with adhesion pads. In addition, the first joint has one small seta, and the second eight setae on its border which increase in size towards the median line. The two-jointed endopod has one and four plumose setae respectively. The fourth swimming legs are smaller than the third pair, with both exopod and endopod one-jointed, and with nine and four setae respectively, but without adhesion pads or sensory bulbs. In place of the latter a seta is found to be present.

Total length, 4.6 mm. Length of carapace, including second and third segments, 2.2 mm. Width of carapace, 2.6 mm. Greatest width of fourth segment, 1.2 mm. Length of plates on fourth segment, 0.7 mm. Length of genital segment, 2.2 mm. Width of genital segment, 1.5 mm. Length of abdomen, 0.4 mm.

Remarks: Four species of *Nesippus* are more closely related than others within the genus, and together constitute a well-defined group. These are *N. orientalis* Heller, *N. alatus* Wilson, and the two new species, *N. australis* and *N. incisus.*

Family Anthosomidae

Genus **Anthosoma** Leach, 1816

Anthosoma crassum (Abildgaard)

Caligus crassus Abildgaard, 1794, p. 54, pl. 5, figs. 1-3.

Anthosoma smithii Leach, 1816, p. 406, pl. xx, fig. 1.

Anthosoma crassum, Steenstrup and Lütken, 1861, p. 397, pl. 22, fig. 24.

Locality, Host and Record of specimens: Eight females from inside lower jaw of Mako Shark (*Isuropsis mako*); French Pass, Cook Strait, New Zealand. Collected by A. M. Rapson, 27.3.1946. Australian Museum Reg. No. P. 13,224. 2 females from a shark; Port Jackson, New South Wales. Australian Museum Reg. No. G. 5,211. 4 females from mouth of shark, *Carcharias*; probably from New South Wales. Australian Museum Reg. No. P. 13,231. 1 female from mouth of shark, *Isuropsis bideni*; South Africa. Australian Museum Reg. No. P. 13,226. 5 females from jaw of Mako Shark (*I. mako*); off Long Reef, near Port Jackson, New South Wales, 12.11.1938. Australian Museum Reg. No. P. 11,015.

Remarks: This is a very common copepod with a cosmopolitan distribution. Although it has not been recorded before from Australian seas, G. M. Thomson states that numerous specimens have been collected in New Zealand waters. The abundant representation in the present collection shows the species to be an equally prevalent member of the Australian marine fauna.

Family Cycnidae Kröyer, 1863

(= Pseudocycnidae Wilson, 1932)

Paracycnus gen. n.

Type species *P. lobosus* sp. n.

This genus, based only on the female sex, is very closely related to *Cycnus* and *Pseudocycnus.* The head is fused with the first segment, only the second segment being free, and the rest of the segments are fused with the genital segment into a cylindrical body several times longer than wide and uniform in diameter. The fused abdomen is one-segmented, the border line being distinguishable only by an invaginated ring. The caudal rami are also coalesced

to the abdomen, and they are long, large and fleshy. Egg-strings are long, with the eggs placed linear-fashion and strongly flattened. The first and second antennae are somewhat like those of *Cycnus*, except that in *Paracycnus* the second antenna has three joints. Also, as in *Cycnus*, the maxilla is very small and, similarly, the first maxilliped, but in *Paracycnus* the latter is placed at the base of an enormously large, three-jointed, second maxilliped. The first legs are uniramose, as in *Pseudocycnus*, but much longer, and jointed. Pairs of biramose, unjointed appendages occur on the second, third and fourth segments.

Although *Cycnus* and *Pseudocycnus* are known to the author only from the literature, it is considered that they are markedly different from *Paracycnus*, and so justify its establishment as a new genus.

Bassett-Smith's *Helleria* is another genus with some striking resemblances to the new *Paracycnus*. However, if Bassett-Smith's text and figures are followed, there appears to be too many differences for the two to be united. The final answer to this can come only from an examination of Bassett-Smith's specimens. From his description one learns that in *Helleria* the first segment is not fused with the head, the trunk is much shorter, and small differences are found in the appendages.

Following is a comparison of characters of the four genera discussed above:—

	Cycnus	*Paracycnus*	*Helleria*	*Pseudocycnus*
1 segment ..	Fused with head	Fused with head	Not fused with head	Fused with head
Following segments	2, 3 segm. free, rest fused with genital segm.	2 segm. free, rest fused with genital segm.	1, 2, 3 segm. free, rest fused with genital segm.	2, 3 segm. free, rest fused with genital segm.
A_1 ..	Several joints ..	Several joints ..	As in *Paracycnus* ..	Few joints.
A_2 ..	Subchela	Subchela	Like *Paracycnus* ..	Subchela.
M_x ..	Vestigial	Vestigial	3-jointed, small ..	Vestigial.
M_{xp1} ..	Vestigial	3-jointed, small ..	3-jointed, small ..	3-jointed, small
M_{xp2} ..	Delicate	Enormously large ..	Large, like *Paracycnus*, except for the basal joint.	Well developed.
Pe_1 ..	Bifurcate ..	Uniramose, 4-jointed.	Pe_2 uniramose ..	Uniramosal, 1 joint.
Pe_{2-4} ..	Bifurcate, jointed ..	Bifurcate, unjointed.	Pe_3 missing, Pe_4 uniramose.	Pe_2 bifurcate, unjointed. Pe_{3-4} uniramose.

Paracycnus lobosus sp. n.

(Figs. 182-190)

Locality, Host and Record of specimens: Three specimens on *Scomberomorus commerson*, from Cape Direction, North Queensland. Collected by A. G. Nicholls, 6.11.1948. Four female specimens, one selected as the holotype, from Torres Strait. Collected by A. G. Nicholls, 22.11.1948. 16 specimens; Torres Strait. Collected by A. G. Nicholls, 23.11.1948. One specimen on *Scomberomorus queenslandicus* at Eden Reef and Princess Charlotte Bay, North Queensland. Collected by A. G. Nicholls, 6.11.1948.

Female: The carapace is ovate, narrowed anteriorly, with the lateral margins curved into well-rounded lobes, and terminating with the posterior corners prolonged into well-rounded lobes; the narrow portion between the posterior lobes represents the first segment, and carries the first legs. The second segment is free, a little wider than the carapace, and the free lateral margins are drawn out into postero-laterally pointing lobes. The third and the fourth segments have the same kind of lateral lobes, but those on the third segment are double. The main parts

of these segments, together with the fifth segment and the genital segment, are fused into a long cylindrical body several times longer than wide and uniform in diameter. The abdomen is also fused with this cylindrical trunk, but is attached to it a little on the ventral side. From this very short, one-segmented abdomen (fig. 186) there extends a pair of long fleshy caudal rami; their greatest width is at the base, and they taper off towards their tips.

The first antenna is long, slender and seven-jointed, with a large horn-shaped seta on the second joint. Further, all the joints except numbers one, two and four are furnished with common setae. The second antenna is three-jointed and strongly prehensile. The first joint is short, the second about twice the length of the first, and the third joint is shaped into a curved claw with an accessory spine midway along its concave side. This third joint is very movable, and can be bent backwards to form a subchela with the second joint. The mouth-cone is short, and on each side of it the maxilla is only a vestigial bud. The next visible part is the enormous second maxilliped, which has a basal joint running as a lateral lamella on the ventral side of the head. Then follows a large swollen second joint tipped with a hook-shaped claw with an accessory spine placed in the same position as the one on the second antenna. The second maxillipeds and the second antennae are the large prehensile organs of the copepod. At the inner base of the second maxilliped is found a small three-jointed organ which is the vestigial remains of the first maxilliped.

The first pair of limbs is uniramose and four-jointed. The second, third and fourth limbs consist of a sympodial bulb with two small unjointed lobes, the exopod and the endopod, each furnished with a short seta.

Length of head, 0.9 mm. Greatest width, 1.1 mm. Length of free segment, 0.5 mm. Length of trunk, 5 mm. Width of trunk a little less than 1 mm.

Male: Unknown.

Hyponeoidae fam. n.

In the collection received from the Australian Museum was a sample from the Australian Antarctic Expedition, 1911-14, containing some parasitic copepods in a rather poor state of preservation. At first glance they appeared to be closely related to the Chondracanthidae, but on examination they proved to belong to the suborder Caligoida, though they would not fit into any of the known families of that group. Although no male was found in the material, it was felt necessary to establish the new family Hyponeoidae in order to deal with the material.

Female: Head covered with a carapace dorsally, having lateral and anterior lobes. First and second thoracic segments free, but partly fused together dorsally; ventrally, a distinct suture shows the partition between them. The second thoracic segment with lateral lobes. The third, fourth and fifth thoracic segments are coalesced with the genital segment into a trunk. No dorsal plates are present. The abdomen consists of one to a few segments terminating with swollen caudal rami.

The first and second antennae consist of several joints, the second terminating with a powerful, prehensile claw. Labium and labrum shaped into an elongated tube enclosing the mandibles. Maxilla bifurcate but plumb. Maxillipeds with powerful terminal claws, especially the second maxilliped, which has its terminal claw bearing against a large and swollen basal joint to form a chela. First two thoracic segments with vestigial, but biramous, swimming limbs, with the stem of the limbs in the shape of a swollen bulb. The trunk may be furnished ventrally with four pairs of bulbs, which seem to be vestigial in character; their placement also suggests that they should be looked upon as limbs.

The egg-strings are linear and in the type genus are rolled up in a spiral.

Male: Unknown.

Hyponeo australis gen. and sp. n.

(Figs. 191-200)

Locality, Host and Record of specimens: Eight females, including the holotype, found on a fish by the Australian Antarctic Expedition, 1911-14. Australian Museum Reg. No. P. 8,060. No further information is available.

Female: The head is wider than long and covered dorsally with a carapace; its lateral sides are furnished with two forwardly-directed lobes. Behind the head are two free thoracic segments which are partly fused together; the fusion is total dorsally, but on the ventral side the dividing line between the two segments can clearly be seen. The first segment is narrow—about two-thirds the width of the head. The second segment is wider, and furnished with a

pair of lateral lobes turned in an anteriorly-directed curve. Behind the narrowed part of the body is a large trunk comprising a coalescence of the three following thoracic segments and the genital segment. The segmentation can be seen only from a dorsal view as weak, broken furrows crossing the trunk. The genital part of the trunk is provided with a pair of postero-lateral lobes, behind which is a small lobe or bulb on which the genital apertures are found. Towards the abdomen the genital part of the trunk becomes narrow and sunken so that it cannot be seen from the dorsal side. This is due to the part being covered by the egg-coils, which are placed rather dorsally. On the same narrow part of the trunk there is found a pair of lateral lobes pointing partly backwards. The abdomen is unsegmented, short, cylindrical in shape, and tipped with a pair of fleshy caudal rami, the combined width of which is about the same as that of the abdomen. No setae could be seen, but the specimens examined were in a poor state of preservation; there may formerly have been some small vestigial setae attached to the caudal rami.

The first pair of antennae is long and slender, consisting of six joints; all except the short and squarish terminal joint are of nearly equal length. Two short, spiny setae were found on the medial margins of the second, third and fourth joints. The terminal joint is furnished with many setae, with the shorter ones on the medial margin; the tip of the joint carries three long and slender setae and two shorter ones. The second antenna is a true prehensile organ, consisting of four joints. The first and second joints are short, the two terminal joints long, and the fourth joint shaped into a strong sickle-shaped claw.

The labium and labrum are drawn out into a proboscis enclosing the stylet-shaped mandibles. The maxillae are placed on each side of the mouth-cone, each consisting of an elliptical bulb with two small, clawed fingers—the exopod and the endopod. Like the maxillae, the first maxillipeds are also diminutive; they are placed posteriorly, a little lateral to the maxillae. Each of them consists of three joints, of which the terminal one is a curved claw, pointing anteriorly, and may be prehensile. From the shape, however, the function seems to be more of an aid in feeding, possibly to hold the skin of the host extended, so the mandibles can cut more easily through it. The second maxillipeds are large prehensile organs, each consisting of three joints—a large swollen basal joint, followed by a short joint carrying a large sickle-shaped claw with a small accessory bulb on the concave side near its tip. The appendage functions as a sub-chela, with the hook of the claw pressed up against the lateral margin of the basal joint of the limb, and is comparable to that found in the caligids.

Each of the first two thoracic segments has one pair of limbs. They consist of a large swollen protopod, which is much larger on the limb of the second thoracic segment than on the first. The big swollen protopod is furnished on both segments with a small vestigial exopod and endopod, both consisting of two joints. No setae are seen on the limbs, a state which may be due to the poor preservation of the specimens.

On the ventral side of the trunk four pairs of bulbs are present, of which the most posterior pair are rather small, and from their placement and number appear to be vestigial appendages. Their slightly nodular surfaces suggest that they may be of a sensory nature.

The egg-strings are long, linear, curled up in a short spiral placed dorsally on the abdomen and thus obscuring this part of the body from view.

Male: Unknown.

Family Eudactylinidae

Genus Nemesis Risso, 1826

Nemesis lamna Risso

(Fig. 201)

Nemesis lamna Risso, 1826, p. 135, pl. 5, fig. 25.

Nemesis mediterranea Heller, 1865, p. 220, pl. 21.

Nemesis lamna, Wilson, 1932, p. 461, pl. 32.

Locality, Host and Record of specimens: 12 specimens, including two males, were found on a shark at Port Jackson, New South Wales. Australian Museum Reg. No. P. 13,232.

Remarks: This copepod is known from the Mediterranean, and European seas, as well as from the Californian coast and the Atlantic coast of Massachusetts, U.S.A. The present record from Port Jackson, New South Wales, Australia, strongly indicates that the species will ultimately prove to be one of cosmopolitan distribution.

Family Dichelesthiidae

Genus **Hatschekia** Poche, 1902

Hatschekia elongata sp. n.

(Figs. 202-206)

Locality, Host and Record of specimens: One female, the holotype, from a Leather Jacket fish (*Brachaluteres jacksonianus*), washed ashore at Cronulla Beach, near Port Hacking, New South Wales, 28.2.1932. Australian Museum Reg. No. P. 13,229.

Female: The single female of this small species is less than 1½ mm. long. It was found to be in a rather bad state of preservation, and this difficulty has prevented the preparation of a full description. The cephalon is small, wider than long, and followed by an oval trunk carrying a pair of egg-strings. No abdomen could be seen.

The first antenna is seven-jointed, its distal joint being tipped with four swollen sensory setae. The second antenna has a long and slender basal joint, tipped with a terminal hook-shaped claw. The maxilla is vestigial, consisting of a short basal joint with the exopod and endopod extended as two branches of a fork. The exopod is a little larger than the endopod. Both are one-jointed, and tipped with a single blunt spine. The maxilliped is three-jointed, with a large basal joint followed by a slender second joint, and terminated by a third short joint with two awkward-looking setae.

Male: Unknown.

Family Lernaeidae

Genus **Lerneaenicus** Le Sueur, 1824

Lerneaenicus hemiramphi Kirtisinghe

(Figs. 207-208)

Lerneaenicus hemiramphi Kirtisinghe, 1933, p. 550, Figs. 4-7.

Locality, Host and Record of specimens: One female, removed from the eye of a Garfish, *Hemiramphus intermedius;* St. Vincent Gulf, South Australia. South Australian Museum collection.

Female: The single female of this species resembles Kirtisinghe's description and figures in most of its characters. The head is the same, including the three characteristically-placed horns and the appendages.

The eye was not clearly seen, but a doubtful spot was found where it may have been located. This organ is commonly present in *Lerneaenicus.* It is, however, likely to disappear in older specimens when, as a parasite, the copepod has its head deeply embedded in the host. The single individual on which the present record is based is an old museum specimen with no remaining pigmentation. The mouth is rather characteristic, with a wide, circular, chitinous-lined pharynx. It has strong muscles which, on the surface round the mouth-opening, take the shape of small knobs.

The species has a close resemblance to *L. polynemi* Bassett-Smith, but the thoracic limbs in that copepod are well developed, with the first and second limbs two-branched, and each of them two-jointed. Also, the third and fourth limbs are single-branched and three-jointed. In *L. hemiramphi* all limbs are unbranched buds.

Specimens of *L. hemiramphi* recorded by Kirtisinghe were from *Hemiramphus xanthopterus*, a fish host closely related to the host of the present single parasite from South Australian waters.

Genus **Lernaeolophus** Heller, 1863

Lernaeolophus sultanus (Nordmann)

(Fig. 209)

Pennella sultana Nordmann, 1864, p. 485, pl. 5, figs. 12-16.

Pennella sultana, H. Milne-Edw., 1840, p. 523.

Lernaeolophus sultanus, Heller, 1865, p. 251, pl. 25, fig. 7; *Id.*, Brian, 1906, p. 91; *Id.*, Wilson, 1917, p. 91, pl. 13, figs. 108-113.

Locality, Host and Record of specimens: One female from lower lip of a Toado Fish (*Tetraodon*); Lord Howe Island, east of New South Wales, Australia. Australian Museum Reg. No. P. 13,222.

Remarks: This species is known from the west coast of Europe, the Mediterranean and the east coast of North America. The present Australian locality is the first known one for the species outside the Atlantic Ocean and adjoining seas. The record provides another instance of a far wider distribution for a species than previously believed.

Family Pennellidae

Genus **Pennella** Oken, 1815

Pennella instricta Wilson

Pennella instricta Wilson, 1917, p. 122, pl. 18, figs. 141-147.

Locality, Host and Record of specimens: Seven specimens from skin of a Black Marlin Swordfish (*Istiompax australis*); off New South Wales coast; Australian Museum Reg. No. P. 11,013. Two specimens found embedded in skin of Striped Marlin Swordfish (*Marlina zelandica*); off Port Jackson, New South Wales, 1940; Australian Museum Reg. No. P. 11,291. Two specimens belonging, with little doubt, to this species; the cephalothorax on both was missing, thus preventing absolute certainty of determination. They were found on a Black Marlin Swordfish (*Istiompax australis*) off Broughton Island, near Port Stephens, New South Wales; Australian Museum Reg. No. P. 11,804.

Remarks: The species has been recorded before only by Wilson from the Atlantic coast of the United States of America. The host for Wilson's specimens was the Atlantic Swordfish (*Xiphias gladius*).

Pennella remorae Murray

(Figs. 210-213)

Pennella remorae Murray, 1856, p. 229, 5 figures in text.

Locality, Host and Record of specimens: One female from a Sucker Fish (*Remora remora*) removed from a shark, probably the Mako Shark (*Isuropsis mako*); Bay of Islands, New Zealand. Australian Museum Reg. No. P. 13,228.

Female: The single specimen at hand clearly indicates that the species is a small one, length only 13.5 cm. The head is globular and bears short minute papillae on the ventral side. The papillae (fig. 211) are arranged in four groups—two larger lateral groups and smaller dorsal and ventral groups. All four groups are further placed together inside a larger ring of papillae. Also on the head are three short, blunt horns—a medial one pointing backwards and the other two pointing outwards from each side. The neck is about one-fourth of the total length of the copepod, increasing posteriorly in width and gradually descending into the wider trunk. The abdomen is short—about 3 cm. long—and covered on its ventral and lateral surfaces with a thick fringe of plumose appendages, in front of which are the two egg-strings, extending from the posterior part of the trunk. A clearly pointed rostrum (fig. 212) is present on the head, and from each of its sides extends a three-jointed, sub-chelate second antenna. No trace of first antennae could be found, although these may be found in some younger specimens and could have been broken off the present female example. The four pairs of thoracopods present were very diminutive (fig. 213) and uniramous. Of the first two pairs, the left one of each has a small second joint. A small second joint is also present in the right leg of the third pair. The fourth pair was found to be only one-jointed and very diminutive.

Remarks: Special characteristics of this species are the arrangement of the papillae on the head, the position of the three horns, the particularly well-developed rostrum, second antenna, and the strongly reduced thoracopods.

When Murray described this species in 1856, he stated that it was found attached to the sucking disk of a Sucker Fish (*Remora remora*). However, all that he described and figured of the copepod was that portion of it that was free of the disk; the part buried in the tissues of the fish host was destroyed in an attempted dissection. Further, the posterior free portion of the parasite had characters plainly showing that the material Murray described was immature, the plumose appendages having only just started to grow. For these reasons Wilson (1917) reiected the species as invalid. The female on which the present record is based is a fully-grown specimen complete with egg-strings. While it cannot be claimed to fit the species as described by Murray, it was found parasitic on the same kind of fish host. Although this vexed question of synonymy can never be finally proved, the present author feels justified in assuming that the New Zealand specimen recorded here represents the adult stage of Murray's *P. remorae*, and refrains from erecting a new species for its accommodation.

Genus **Trifur** Wilson, 1917

Trifur physiculi sp. n.

(Figs. 214-220)

Locality, Host and Record of specimens: Three female specimens, including the holotype' from the skin of a fish, *Physiculus*; Twofold Bay, New South Wales; collected by W. S. Fairbridge, 27.1.1949. Four specimens from *Physiculus barbatus* (Red Rock Cod); D'Entrecasteaux Channel, Tasmania; collected by A. M. Olsen, 4.11.1948. Three specimens from skin, same host; Corner Inlet, Victoria; collected by M. Blackburn, October, 1948. Two specimens, same host; Hobart, Tasmania. Australian Museum Reg. No. G. 3,926. Eleven specimens, parasitic on local Cod (*Physiculus*); Oyster Bay, Tasmania, 11.7.1909. Australian Museum Reg. No. E. 6,794.

The species is very close to Wilson's *Trifur tortuosus*, on which the genus was established. There are, however, small differences in the shape of the horns and of the appendages, which justify the establishment of a new species.

Female: The cephalothorax is enlarged, nearly at right angles to the neck, and armed with a dorsal posterior median horn and two conical lateral horns. The posterior horn is slightly curved and directed backwards; it is conical, and bluntly rounded at the tip. The two lateral horns are a little variable in shape and size. They may be either longer and thinner than the posterior horn, with a somewhat drawn-out appearance, or they may be shorter, more conical, rather thick at the base, and end bluntly. The mouth-cone is like a big bell; it is bent, and points backwards ventrally. The neck is long, about twice the length of the trunk, and that part outside the flesh of the host may by growth be curved in two or three different directions. The cephalothorax is perfectly smooth, without knobs or horns. The front part of the trunk or the genital segment is somewhat like that of *Lernaea*, but is less swollen and perfectly smooth except for a pair of processes placed laterally to the oviduct openings. It is also compressed a little laterally and shaped in a semi-circle. The abdomen is fleshy, club-shaped and enlarged a little at the tip. It is without any knobs or processes, and about half the diameter of the genital segment. The same structure is also bent in a half circle where it leaves the genital segment, and is straight for the rest of its length.

The egg-strings are each curled in an open spiral. The anal laminae are so small that they can scarcely be seen, but there is a tiny single-haired bulb on each side of the anus. Unfortunately, Wilson has not given any detailed figures of the appendages of his *T. tortuosus*; he describes them only in the text. In the present *T. physiculi* the first antenna is very short and unjointed. Wilson states that *T. tortuosus* has an indistinctly jointed first antenna, but this appendage in both species is turned outwards away from the midline. Further, in *T. tortuosus* it is tipped with four small setae. The second antenna, placed inside the first antenna, is rather large and three-jointed, consisting of a larger basal joint, and the chela which is comprised of the following two joints. Both the first and second antennae are placed on a semi-globular dorsal swelling of the cephalothorax (see fig.).

The four pairs of swimming limbs are strongly reduced in this species. All of them are uniramose and thus differ from Wilson's species, but each of the limbs is two-jointed, with a larger basal joint and a smaller distal joint; no setae could be seen on the specimens examined. The first two pairs of limbs are placed above the bend of the neck towards the cephalothorax, with the proboscis reaching down to a point where it is level with them. The last two pairs of limbs are placed a little more apart and below the bend of the neck.

Total length when fully extended, 30-40 mm.

Male: Unknown.

IV Suborder LERNAEOPODOIDA

Family Lernaeopodidae

Lernaeopodella gen. n.

Type species *L. major* sp. n.

Generic characters—female: Cephalothorax at an oblique angle with the trunk but much smaller, the two parts separated with a distinct groove. The dorsal carapace is small and poorly defined. Trunk long, like *Lernaeopoda*, but the first two segments are not so clearly separated from the rest. Two posterior processes are found in a ventral position to the egg-strings, and these extend from the genital process itself.

First antenna three-jointed, with a swollen basal joint. Second antenna with a three-jointed protopod, a one-jointed endopod at the termination of the protopod, and a thumb-shaped, two-jointed exopod. Each of the first maxillae on a long shaft. Second maxillae shaped in long free arms connected together only by the bulla. Maxillipeds placed together on an unpaired ventral process. Each maxilliped is two-jointed, and tipped with a small claw. Egg-strings stout.

The copepod appears to be one that reaches a relatively large size.

Male: Unknown.

Lernaeopodella major sp. n.

(Figs. 221-224)

Locality, Host and Record of specimens: Three females, including the holotype, found on a shark at Eden, New South Wales. Australian Museum Reg. No. P. 3,717.

Female: The cephalothorax is small, ovoid, flattened dorso-ventrally, and covered dorsally with a carapace which does not reach very far down on the sides; it is inclined at nearly right angles to the trunk axis. The first two segments of the trunk are differentiated from the rest of the trunk, but not very distinctly. The segments that follow are coalesced with the genital segment, and are only partly indicated by surface grooves. The trunk as a whole is cylindrical, more or less strongly flattened dorso-ventrally, and about three or four times as long as wide; its posterior end has prominent, well-rounded corners. In the centre, between but a little ventrally from the bases of the egg-strings, two ventral posterior processes extend from a median bulb or genital process, in which there is a deep cleft. The egg-strings are about equal to the length of the body, slender, cylindrical and with many rows of minute eggs.

The first antenna is three-jointed, with a thick swollen basal joint followed by two delicate joints, but the appendage is not tipped with any setae. The second antenna is remarkable in that it has a distinctly three-jointed protopod. The first two joints of this latter are short, and the third joint about equals the combined length of the first two joints. The exopod is two-jointed, the endopod only one-jointed but more swollen at the tip than at the base; the two together look like a hand with a free thumb. The mouth-tube is short, swollen and thick. The mandibles are normal, but have only four teeth. The first maxilla is on a long shaft, and tipped with three fingers, each of them terminating with a small claw. The second maxillae are a pair of long, slender, entirely separated arms joined together only by the bulla which, unfortunately, was missing in all three specimens examined; the structure must have been lost when the copepods were removed from the host.

The maxillipeds are relatively short and extend from far behind. They are placed on a large fleshy bulb which makes it possible for them to reach the mouth-cone. Each of the appendages is two jointed, and tipped with a little claw. The first joint is much swollen, with two short but strong spines on the flattened postero-lateral margin. The second joint functions as a clasping sub-chela which bears against the first joint. It is of the usual shape of such joints, and tipped with a short claw.

Of the three specimens measured, the one medium in size was the one selected as the type. Its dimensions are: Total length, 5.5 mm. Length of cephalothorax, 1.7 mm. Length of trunk, 4 mm. Width of trunk, about 2 mm. Length of posterior processes, 2.5 mm

No male was found on any of the three females examined.

Genus **Tracheliastes** Nordmann, 1832

Tracheliastes chimaerae sp. n.

(Figs. 225-232)

Locality, Host and Record of specimens: Approximately 50 specimens, including the holotype, found on the clasper of a Ghost Shark (*Chimaera ogilbyi*), 30 miles south of Cape Everard, Victoria, 270 fathoms, 22.10.1914; trawled F.I.S. " Endeavour ". Australian Museum Reg. No. E. 5,975.

Female: The cephalothorax is very minute, with no dorsal carapace, but has a long proboscis curved forwards ventrally between the second maxillae. It is separated from the trunk on each side by a deep invagination, and also by a dorsal and ventral groove. The trunk is large, massive, and strongly flattened dorso-ventrally; posteriorly, it becomes gradually enlarged and then slightly contracted. The posterior margin is almost squarely truncated, with

rounded corners and a wide medial rounded lobe extending into a small two-lobated genital process. No posterior processes, abdomen or anal laminae are present. The convolutions of the oviducts form a series of slight rounded swellings, and are seen along each side of the median line. The swellings are all of about equal size along the trunk, and are of a darker colour than the rest of the trunk. The egg-strings are stout and very long—longer than the trunk and containing many small eggs. In the adult females very little seems to be left of the appendages; first and second antennae, and also the first maxillae, are missing. The mouth-cone is a long proboscis of about equal diameter, except for near its extremity, where it terminates in a conical tip. The upper lip is relatively large, for it makes up nearly one-third of the cylinder of the mouth-tube. The anterior opening of the mouth-tube is fringed with fine hairs. The mandibles are very long, extending into the usual position at the base of the mouth-tube, and reaching as far as the tip of the mouth-cone. Only three strong teeth are left at the tip of the mandible. The second maxilla consists first of a little bulb with the maxillary gland at its opening, after which follows a long fleshy arm curved round the mouth-tube and what is left of the cephalothorax. The two maxillary arms are entirely free. The bulla has a long thin stalk extending into a large globular bulb.

The maxilliped, which is placed behind the second maxilla, is minute and three-jointed. The first joint is stalk-like, and is followed by a swollen joint that appears to have once been combined with the claw of the third joint to form a sub-chela. Altogether, the whole appendage is vestigial and of little functional use.

In a young female with bulla not fully formed, indicating recent attachment to the host, some more details of structure can be seen. The cephalothorax points forwards, but is naked and without carapace. The mouth-tube is small, as in other Lernaeopodidae. The first antenna is three-jointed and slender, with the two first joints equal in length, and the length of each nearly three times their diameter. The third joint is a small tipped claw. The second antenna is bifurcate, and has a short single-jointed protopod with two large branches. The exopod is bulbous, but has a half-moon incurvation on the ventral side near the tip which is provided with two small setae. The endopod is a little longer than the exopod and tipped with a claw and a small accessory spine behind the claw. No first maxilla could be found.

Length of proboscis, 1.7 mm. Length of trunk, 6 mm. or more. Width of trunk, about 4 mm.

Male: The male sex represented in the material of the present new species is the first to be known for the genus. The cephalothorax is egg-shaped, naked, and pointed anteriorly. The trunk is elongated, and at least three segments can be distinguished. Posteriorly, it is tipped with a pair of small three-jointed anal laminae.

The first antenna is three-jointed as in the female, with the terminal joint tipped by a claw. The second antenna is different from that of the female in that both the endopod and the exopod are two-jointed. In consists of a short unjointed protopod, followed by the two branches. The exopod has a short swollen basal joint, and a thin finger-shaped distal joint. The endopod is also two-jointed, and has a swollen basal joint like that of the exopod, but longer than the combined length of both exopodal joints. The second endopodal joint is of a peculiar chelate form, but without any movability in the finger of the chela. The chela is further furnished with a long slender accessory spine.

The first maxilla is a long, stalked, three-partite organ, but without any division into joints. The second maxilla is three-jointed, its basal joint wrinkled and like a stalk. The second joint of the maxilla is large and swollen, and the third is a sickle-shaped claw. The maxilliped also has three joints, all smaller than those of the second maxilla, but otherwise of the same shape.

Total length, about 0.8 mm. Length of cephalothorax, about 0.4 mm. Length of abdomen, about 0.4 mm.

Genus **Brachiella** Cuvier, 1830

Brachiella cirrocauda sp. n.

(Figs. 233-236)

Locality, Host and Record of specimens: 12 females (some with males), including the holotype, from inside the mouth of a Red Rock Cod (*Physiculus barbatus*); Corner Inlet Victoria. Collected by M. Blackburn, Oct., 1948.

Female: The cephalothorax is stout, cylindrical and considerably longer than the trunk. The head, compared with the rest of the cephalothorax, is enlarged and covered with a carapace. The neck is flexible and usually bent ventrally. The second maxillae are short, with the arms separated. The trunk is short, wider than long, and a little flattened dorso-ventrally. It has

two ventral posterior processes, and between them a small one-segmented genital process. The posterior processes are about as long as the trunk or a little longer, and straight. Laterally and dorsally to the posterior processes are the egg-strings which, in most cases, are longer than the processes and contain many small eggs.

The first antenna is somewhat swollen at the base, three-jointed, and with the first joint much thicker than the following ones; the terminal joint is tipped with four short setae. The second antenna is biramose and turned down over the frontal margin. The appendage extends from its base with a two-jointed protopod—first a short joint, followed by a longer joint about three times the length of the basal joint. Of the unarmed endopod tipping the protopod, the dorsal ramus is large, bluntly rounded and one-jointed. The ventral ramus of the exopod is comparatively minute, two-jointed and terminated by a tuft of small setae, of which the most lateral seta appears to be the largest.

The mouth-tube is long and cylindrical, and reaches the exopod of the second antenna. The lower lip is fleshy, large at its tip and fringed with hairs. The upper lip is also fleshy, but perhaps a little more narrow than usual. The mandibles are of the usual type, reaching to the opening in the mouth-tube. The first maxilla is three-partite. The palps are one-jointed, and each is tipped with a single spine. The second maxilla is short and slender, and the arms separate except at their tips. The bulla can be compared with a stalked cone of the cypress-like kind, the short stalk at the base of the cone being situated between the cone and the maxilla. The openings of the maxillary glands are surrounded by a small circular wall, and are not prominent in this species.

The maxillipeds are relatively large, each consisting of three joints. The basal joint is large and swollen, with two ridged patches and a short spine in between on their medial margin. The second joint is about half as long as the basal joint and, combined with a prolongation of the third joint, takes the form of a sub-chela having only a slightly curved, strong claw. On the distal half of the medial margin of the second joint there is a comb of cross-ridged teeth which fits into the distal pad on the basal joint. The tip of the terminal claw reaches the proximal pad on the same joint, an arrangement which clearly improves the grasp of the maxilliped.

The specimens examined varied much in size, but the following measurements apply approximately to a well-grown female: Length of cephalothorax, 4 mm. Width of cephalothorax, 0.6 mm. Length of carapace, 1 mm. Length of trunk, 2 mm. Width of trunk, 2.5 mm. Depth of trunk, about 1 mm. Length of posterior processes, about 2 mm. Length of egg-strings, 2-3, 5 mm. Width of same, 0.8 mm.

Male: The head is placed at an angle of nearly 90 degrees to the body axis. It is covered with a distinct dorsal carapace, which is extended anteriorly into a small rostrum. The trunk is ovate, and ends in a pair of well-shaped anal laminae, which are conical and at right angles to the trunk axis.

The first antenna is slender and three-jointed, the first joint being about twice as long as the following ones. The distal joint is tipped with four setae as in the female, but those of the male are conical in shape and definitely sensory. The second antenna is a much larger appendage, and biramose. The protopod consists of two joints (coxa and basis) of about equal size, followed by a one-jointed, smoothly-rounded endopod and a three-jointed exopod. The second joint of the exopod is furnished with a spiny sensory bulb on its distal posterior margin. This sensory bulb is underneath the claw which tips the exopod, and forms the third joint. If the male exopod is compared with that of the female, the claw on the male appendage must be homologous with the single, large, most lateral spine and the tuft of setae found in the female.

The mouth-cone is large and the upper lip is divided into two parts; there is a proximal larger part and a distal smaller one, divided from each other by a dorsal groove crossing transversely the upper surface of the upper lip. The frontal opening of the mouth-cone is strongly fringed with setae. The first maxilla is large, and reaches the distal tip of the mouth-cone. Its protopod is spindle-shaped, comprising an original two joints, and is tipped with three fingers—exopod, endopod, and an endit from the basis—all of which are one-jointed and tipped with a claw. The second maxilla is two-jointed, sub-chelate, and is the largest of the appendages. It consists of a large swollen basal joint, and a claw-shaped finger which is bent backwards towards the basal joint. The maxilliped is also two-jointed, more slender than the maxilla, and chelate. The chela, however, is not of the ordinary kind, for the basal joint is furnished with a forwardly-directed lobe on its medial margin, against which the claw of the distal joint clasps.

Length of carapace, 0.6 mm. Length of rostrum, 0.07 mm. Length of trunk, 0.6 mm. Length of mouth-cone, 0.27 mm. Length of first antenna, 0.14 mm. Length of second antenna, 0.18 mm. Length of first maxilla, 0.16 mm. Length of second maxilla, 0.25 mm. Length of maxilliped, 0.3 mm.

Brachiella cirrata sp. n.

(Figs. 237-245)

Locality, Host and Record of specimens: 17 females (some with males), including the holotype, from the skin and inside the mouth of a Red Rock Cod (*Physiculus barbatus*); D'Entrecasteaux Channel, Tasmania. Collected by A. M. Olsen, 4.11.1948.

Female: The cephalothorax is especially stout towards the trunk, conical, and tapers towards the tip. The head is pointed towards the tip and covered with a large carapace reaching far down on each side. Dorsally, the axis of the cephalothorax is bent towards the axis of the trunk where the two meet. The trunk is strongly flattened dorso-ventrally, with the side wings bent a little ventrally, much wider than long, and extending forwards like a pair of shoulders along the sides of the cephalothorax. Only two small posterior ventral processes are present, and placed between their bases is a small triangular genital process. Dorso-laterally from the posterior processes there extends a pair of very long egg-strings—longer than the whole copepod, and containing a great number of eggs in from 10 to 12 longitudinal rows.

The first antenna is small, three-jointed, and not swollen at the base as in *B. cirrocauda*. Of the three joints the distal joint is the smallest, and is tipped with some short setae. The second antenna is biramose and, as in most species, is turned down across the frontal margin. Its protopod is two-jointed, although the basal joint is not clearly marked off from the head. The same structure is also tipped with a blunt, swollen but smooth one-jointed endopod, and a small exopod extends from the second joint of the protopod. This exopod is two-jointed, the basal joint being much the larger. The distal joint of the exopod is tipped with a small, tiny claw. The mouth-tube is small, conical, neatly-rounded at the tip, and provided with a very thin upper lip. The mandibles are of the usual shape.

The first maxilla consists of a two-jointed shaft which is considered characteristic, as it has not been seen in other species known to the author. Further, the second joint is furnished with four fingers—exopod, endopod, and two endits from the basis. Each of the fingers is one-jointed, and tipped with a claw. The second maxillae are separated throughout their full length and are of very remarkable build. Each of them consists of four bulbs connected with one another through a thin string. Although not clearly seen, it does appear that the maxillary glands open on the tip of the lower bulbs at the point marked *g.* on figure 239. The largest and most distal of the bulbs of each arm clasp a trumpet-shaped bulla. The marked difference from normal structure exhibited by both the first and second maxillae might tempt some future investigators to establish a new genus for the accommodation of this species. The author, however, feels that this is not absolutely necessary because of the present limited knowledge of the genus *Brachiella*.

The maxillipeds have a very elongated basal joint and, in the female, the claw tipping the second joint is coalesced with that joint. Ventrally from the claw the joint extends into a second smaller claw which, in the male, clasps the chela.

Length of cephalothorax, a little less than 3 mm. Length of trunk, about 2 mm. Width of trunk, 3 mm. Length of posterior processes, 1.2 mm. Length of egg-strings, about 5 mm.

Male: The male is relatively large and clumsy in appearance. The head is at right angles to the body axis, and covered with a distinct dorsal carapace which reaches down aganist the thorax beyond the bend of the neck; no rostrum was present. The trunk is large and oval-shaped, ending in a pair of small anal laminae which are conical and at an angle of 45 degrees to the body axis.

The first antenna is longer than usual, slender and three-jointed. It has a swollen basal joint, and a conical second joint with the tip of the cone cut off from the third joint. The third joint is long and cylindrical, with five thick sensory hairs at the tip. The second antenna is biramose, with a two-jointed protopod of which the coxa, as in the female, is short and with no suture showing its separation from the head. The endopod of the same appendage is a smooth-surfaced, rounded bulb, while the exopod is two-jointed and tipped with a claw. The basal joint is half the diameter of the endopod, but of the same length. The second joint is only one-third the length of the endopod, and the claw is sickle-shaped but relatively delicate. The male mouth-cone is short and the first maxilla reaches to its tip. The maxillae have, as in the female, a two-jointed protopod and four long claw-tipped fingers. The second maxillae are short, stout and three-jointed, with the first two joints shaped into a cone tipped with a sickle-shaped claw.

The male maxilliped is of a special shape. It is long and three-jointed, but between the first and second joints there is found a soft-skinned girdle functioning as a globular joint which enables the distal part to move with the chela in all directions. The second joint is shaped so as to function as the basal part of the sub-chela, against which the margin of the finger of the third joint clasps and fits into a groove on the second joint.

Length of carapace, 0.4 mm. Length of trunk, 0.5 mm. Width of trunk, 0.35 mm.

Brachiella stellifera sp. n.

(Figs. 246-250)

Locality, Host and Record of specimens: Four specimens of both sexes, including the holotype, from the gills of a Toado Fish, *Sphaeroides*; Rockingham, Western Australia. Collected by A. G. Nicholls, 1.2.1943.

Female: The cephalothorax of this relatively large species is stout, cylindrical and of about the same length as the trunk. The head is a little enlarged, with a straight-cut front, and is covered with a carapace. Dorsally the cephalothorax is bent backwards from the trunk, which is elliptical and somewhat elongated. Two short ventral posterior processes are found on the trunk, and between them is a very small genital process. The egg-strings are long—longer than the whole copepod, and contain several rows of eggs.

The first antenna is slender, three-jointed and tipped with a single long seta. The second antenna is stout and bent in front of the head. Its protopod contains a short coxa and a basis which is three times longer. The endopod is a bulb with a diameter greater than that of the protopod, and the shape is somewhat like the cap of a mushroom. The exopod is smaller and two-jointed, with the basal joint much thicker than the distal one. The latter joint is short and cut at the tip, where there is a tuft of long and short setae. The mouth-cone is large and fleshy, with the usual ring of hairs at its tip. The first maxillae are furnished with three fingers, each of them terminating in a claw. The second maxillae are rather short, wrinkled, and bifurcate at their tips. They are separated along their entire length, and at their bases is a semi-globular bulb, the maxillary gland, which opens with two thin tubes leading on to the dorsal side of the cephalothorax close up towards the trunk. The bulla is of very artistic build, somewhat like a flattened cup, with its free margin produced into a circle of radiating rays.

The maxillipeds are large and three-jointed, featuring a big basal joint with a little spine in the middle of its medial margin, and a second joint tipped with a claw. The second joint has ridges on its medial margin behind the claw, which are used for clasping against the basal joint to form a sub-chela.

Length of cephalothorax, 3.5 mm. Length of trunk, 3.5 mm. Length of posterior processes, 2 mm. Length of egg-strings, 7-8 mm.

Male: The head is at right-angles to the body axis, and covered with a large dorsal carapace furnished with a rostrum. The anterior part of the trunk is in the form of a narrow neck or waist, while the posterior part is strongly elongated into an elliptical shape. Anal laminae are absent. The first antenna is long and slender, three-jointed as in the female, and tipped with a single seta. The second antenna has a two-jointed protopod, a smooth bulbous one-jointed endopod, and a two-jointed exopod tipped with three fleshy setae. The mouth-cone has a fleshy upper lip, and on the side of the lower lip the first maxilla is found. The latter has three fingers tipped with claws, of which the exopodal and endopodal claws reach a little in front of the mouth-cone. The second maxilla is small when compared with the maxilliped. It is conical in shape and tipped with a medially-pointing, sickle-shaped claw. The maxilliped is the prehensile organ and is three-jointed, with the two distal joints forming a chela.

Length of cephalothorax, 0.5 mm. Length of trunk, 0.8 mm. Greatest width of trunk, 0.2 mm.

Family Sphyriidae

Genus Sphyrion Cuvier, 1830

Sphyrion laevigatum Guerin

Sphyrion laevigatus Guerin, 1840, p. 11, pl. 9.
Lesteira kroyeri Thomson, 1890, p. 370, pl. 28, figs. 4, 4a.
Sphyrion laevigatum, Stebbing, 1900, p. 60, pl. 4.
Sphyrion australicus Thor, 1900, p. 280.
Sphyrion laevigatum, Wilson, 1919, p. 575.

Locality, Host and Record of specimens: One specimen from a fish (species unknown) caught in the Tasman Sea, east of New South Wales. Presented by D. G. Stead, New South Wales State Fisheries. Australian Museum Reg. No. P. 4,899. One specimen from a Ling Fish, *Genypterus*; Great Australian Bight, South Australia. Australian Museum Reg. No. E. 4,760.

Remarks: This large copepod has a cosmopolitan distribution. It is very closely related to *S. lumpi* Kröyer—so closely that if sufficient young material became available for examination it is likely that the two would prove to be one species. This question of possible synonymy must remain a problem for future investigators.

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EXPLANATION OF FIGURES

Abbreviations

CA — Cephalic area
ECA — Eucephalic area
PCA — Post cephalic area
TA — Thoracic area
LA — Lateral area or lateral wings
FP — Frontal plates
FL — Frontal lunules
PL — Posterior lunules
FS — Free fourth thoracic segment
GS — Genital segment
A — Abdomen
AL — Abdominal or anal lamina
AF — Abdominal furca
C — Coxa
B — Basis
Bu — Bulla
Pe_{1-6} — $Pereiopod_{1-6}$ or first to sixth thoracopods

F — Sternal furca
ES — Egg-strings
A_1 — Antennule or first antenna
A_2 — Second antenna
MD — Mandible
L — Labium or upper lip
LB — Labrum or lower lip
MC — Mouth cone
MX_1 — First maxilla or maxillule
MX_2 — Second maxilla
MXP_1 — First maxillipede
MXP_2 — Second maxillipede
R — Rostrum
MG — Maxillary gland
g — Maxillary gland opening
CT — Cephalothorax
T — Trunk

Figs. 1-3. *Argulus macropterus* sp. n. Fig. 1, dorsal view. Fig. 2, ventral view. Fig. 3, first and second antennae.

Figs. 4-7. *Argulus japonicus* Thiele. Fig. 4, dorsal view. Fig. 5, ventral view. Fig. 6, first and second antennae. Fig. 7, maxilliped.

Figs. 8-13. *Pseudoblias lyrifera*, gen. and sp. n. Fig. 8, dorsal view of female. Fig. 9, same viewed partly from lateral. Figs. 10-11, frontal part of female from dorsal and ventral.

Fig. 12, posterior part of trunk with abdomen and part of egg-string of female. Fig. 13, first antenna.

Figs. 14-19. *Acanthochondria gemina* sp. n. Fig. 14, dorsal view of female. Fig. 15, ventral view of frontal part of female. Fig. 16 abdomen of female with anal laminae. Fig. 17, frontal part of male from dorsal, showing rostrum and first and second antennae. Fig. 18, mouth parts of female. Fig. 19, pygmy male.

Figs. 20-26. *Acanthochondria tasmaniae* sp. n. Fig. 20, dorsal view of female. Fig. 21, ventral view of anterior part of female. Fig. 22, ventral view of posterior part of trunk and abdomen of female. Fig. 23, mouth appendages of female. Fig. 24, first antenna of female. Fig. 25, rostrum and second antenna of male. Fig. 26, male in lateral view.

Figs. 27-36. *Alimeda orientalis* gen. and sp. n. Fig. 27, dorsal view of female. Fig. 28, first antenna. Fig. 29, second antenna. Fig. 30, Labium with mouth-appendages. Fig. 31, detail of mandible, maxilla and first maxilliped. Figs. 32-36, first to sixth pereiopods.

Figs. 37-44. *Caligus alveolaris* sp. n. Fig. 37, dorsal view of female. Fig. 38, dorsal view of male. Fig. 39A, frontal part of male from ventral, showing frontal appendages. Fig. 39B, same of female. Fig. 40, second maxilliped of female. Figs. 41-44, first to fourth thoracopods of female.

Figs. 45-53. *Caligus maculatus* sp. n. Fig. 45, Dorsal view of female. Fig. 46, same of male. Fig. 47, posterior part of young female from dorsal. Fig. 48, frontal part of female with appendages from ventral. Figs. 49-51, second to fourth thoracopods of female. Fig. 52, frontal appendages of male. Fig. 53, posterior part of young male from dorsal.

Figs. 54-61. *Caligus lucidus* sp. n. Fig. 54, dorsal view of female. Fig. 55, frontal section of female from ventral, with appendages. Figs. 56-58, second to fourth thoracopods. Fig. 59, posterior part of male from dorsal. Fig. 60, section of same from ventral, showing fifth and sixth pairs of thoracopods. Fig. 61, Posterior part of young female.

Figs. 62-67. *Caligus dentatus* sp. n. Fig. 62, dorsal view of female. Fig. 63, ventral view of anterior section, showing mouth appendages. Fig. 64, first antenna, with sucking disc enlarged. Figs. 65-67, second to fourth thoracopods.

Figs. 68-74. *Caligus probosci* sp. n. Fig. 68, dorsal view of male. Fig. 69, section of same from ventral, showing mouth appendages. Fig. 70, second maxilliped. Figs. 71-74, first to fourth thoracopods.

Figs. 75-82. *Caligus cincabdominalis* sp. n. Fig. 75, female from dorsal. Fig. 76, section of same from ventral, showing frontal appendages. Figs. 77-78, first and second maxilliped. Figs. 79-82, first to fourth thoracopods.

Figs. 83-91. *Caligus sensoris* sp. n. Fig. 83, dorsal view of female. Fig. 84, mouth appendages, seen from ventral. Figs. 85-88, first to fourth thoracopods. Fig. 89A, male from dorsal. Fig. 89B, posterior part of same. Fig. 90, second antenna of male. Fig. 91, second maxilliped of male.

Figs. 92-98. *Caligus cornutus* sp. n. Fig. 92, dorsal view of male. Fig. 93, dorsal view of young female. Fig. 94, genital segment of male, from ventral. Fig. 95, mouth appendages, from ventral. Figs. 96-98, second to fourth thoracopods.

Figs 99-105 *Caligus obovatus* sp. n. Fig. 99, dorsal view of male. Fig. 100, section of male from ventral, showing mouth-appendages. Fig. 101, second antenna. Figs. 102-105, first to fourth thoracopods.

Figs. 106-115. *Caligus longirostris* sp. n. Fig. 106, dorsal view of female. Fig. 107, same of male. Fig. 108, second antenna and first maxilla of male. Fig. 109, second maxilliped of female. Fig. 110, mouth appendages of female from ventral. Fig. 111, second maxilliped of male. Figs. 112-115, first to fourth thoracopods.

Figs. 116-123. *Lepeophtheirus elongatus* sp. n. Fig. 116, female from dorsal. Fig. 117, first antenna. Fig. 118, mouth appendages. Fig. 119, second maxilliped. Figs. 120-123, first to fourth thoracopods.

Figs. 124-134. *Lepeoptheirus molae* sp. n. Fig. 124, dorsal view of female. Fig. 125, ventral view of frontal section of female, showing mouth-appendages in natural placement. Figs. 126-130, first to sixth thoracopod. Fig. 131, male from dorsal and genital segments, from ventral. Fig. 132, first maxilla of male. Fig. 133, second maxilliped of male. Fig. 134, posterior part of young female.

Figs. 135-144. *Caligulus longispinosus* gen. and sp. n. Fig. 135, dorsal view of female. Fig. 136, dorsal view of male. Fig. 137, mouth-appendages of male. Fig. 138, mouth-appendages of female. Figs. 139-140, first and second maxillipeds. Figs. 141-144, first to fourth thoracopods.

Figs. 145-150. *Tuxophorus cervicornis* sp. n. Fig. 145, dorsal view of female. Fig. 146, mouth-appendages from ventral. Figs. 147-150, first to fourth thoracopods.

Figs. 151-153. *Gloiopotes longicaudatus* (Maricawa). Fig. 151, female from dorsal. Fig. 152, ventral view of frontal section with appendages. Fig. 153, fourth thoracopod.

Figs. 154-161. *Perissopus serratus* sp. n. Fig. 154, female from dorsal. Fig. 155, frontal part from ventral showing appendages. Fig. 156, part of genital segment and abdomen from ventral. Fig. 157, first maxilliped. Figs. 158-161, first to fourth thoracopod.

Figs. 162-172. *Nesippus australis* sp. n. Fig. 162, female from dorsal. Fig. 163, ventral view, with frontal appendages. Fig. 164, first antenna. Fig. 165, first maxilla. Figs. 166-167, first and second maxilliped. Figs. 168-171, first to fourth thoracopods. Fig. 172, abdomen from ventral.

Figs. 173-181. *Nesippus incisus* sp. n. Fig. 173A, female from dorsal. Fig. 173B, young undeveloped female. Fig. 175, frontal appendages. Fig. 176, second antenna. Fig. 177, first maxilliped. Figs. 178-181, first to fourth thoracopods.

Figs. 182-190. *Paracycnus lobosus* gen. and sp. n. Fig. 182, dorsal view of female. Figs. 183-185, ventral, dorsal and lateral views of head. Fig. 186, posterior part from ventral. Figs. 187-188, first and second antennae. Fig. 189, second maxilliped. Fig. 190, first thoracopod.

Figs. 191-200. *Hyponeo australis* gen. and sp. n. Fig. 191, female from dorsal. Fig. 192, female from ventral. Fig. 193, ventral view of frontal part, showing appendages. Fig. 194, first antenna. Fig. 195, second antenna. Fig. 196, mouth tube with mandibles. Fig. 197, maxilla. Figs. 198-199, first maxilliped. Fig. 200, second maxilliped.

Fig. 201. *Nemesis lamna* Risso. Female from dorsal.

Figs. 202-206. *Hatschekia elongata* sp. n. Fig. 202, female from dorsal. Fig. 203, first antenna. Fig. 204, second antenna. Fig. 205, maxilla. Fig. 206, maxilliped.

Figs. 207-208. *Lernaeenicus hemiramphi* Kirtisinghe. Fig. 207, female from lateral.

Fig. 208, ventral view of head and anterior part of neck.

Fig. 209. *Lernaeolophus sultanus* Nordman, head of female.

Figs. 210-213. *Pennella remorae* Murray. Fig. 210, female. Fig. 211, frontal part from ventral. Fig. 212, rostrum and second antenna. Fig. 213, first to fourth thoracopods.

Figs. 214-220. *Trifur physiculi* sp. n. Fig. 214, female in total. Figs. 215-218, head with horns and anterior part of neck from different angles. Figs. 219, dorsal view of rostrum, first and second antennae. Fig. 220, third and fourth thoracopods.

Figs. 221-224. *Lernaeopodella major* gen. and sp. n. Fig. 221, female from lateral.

Fig. 222, frontal part of head from ventral. Fig. 223, maxillipeds. Fig. 224, ventral view of posterior part of trunk, with genital process, beginning of posterior processes, and egg-strings.

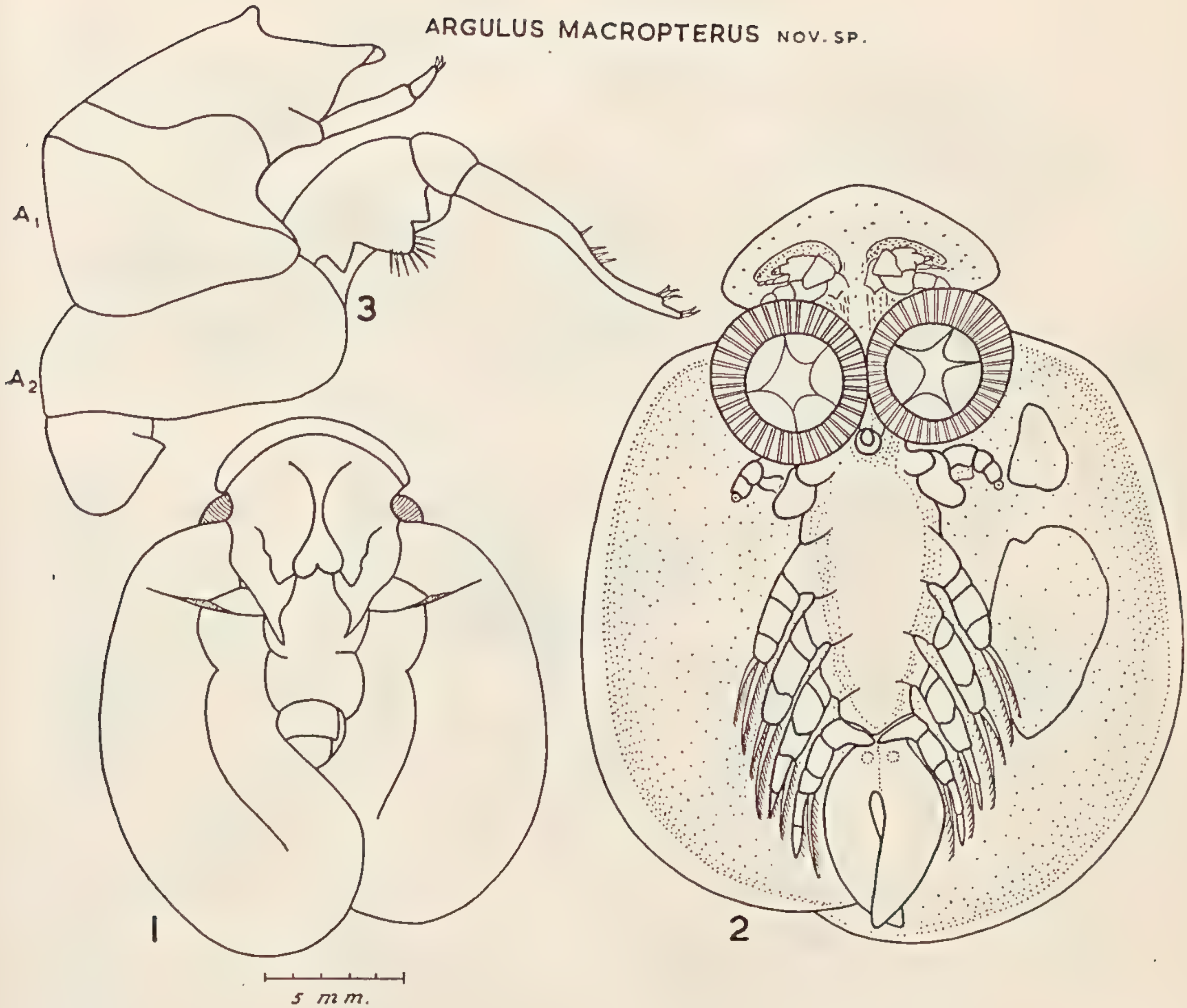
Figs. 225-232. *Tracheliastes chimaerae* sp. n. Fig. 225, female from dorsal. Fig. 226, tip of mouth cone. Fig. 227, young female. Fig. 228, head of young female. Fig. 229, second antenna of same. Fig. 230, maxilliped of female. Fig. 231, male in lateral view. Fig. 232, second antenna of male.

Figs. 233-236. *Brachiella cirrocauda* sp. n. Fig. 233, female. Fig. 234, frontal part of head from ventral. Fig. 235, male. Fig. 236, frontal part of male.

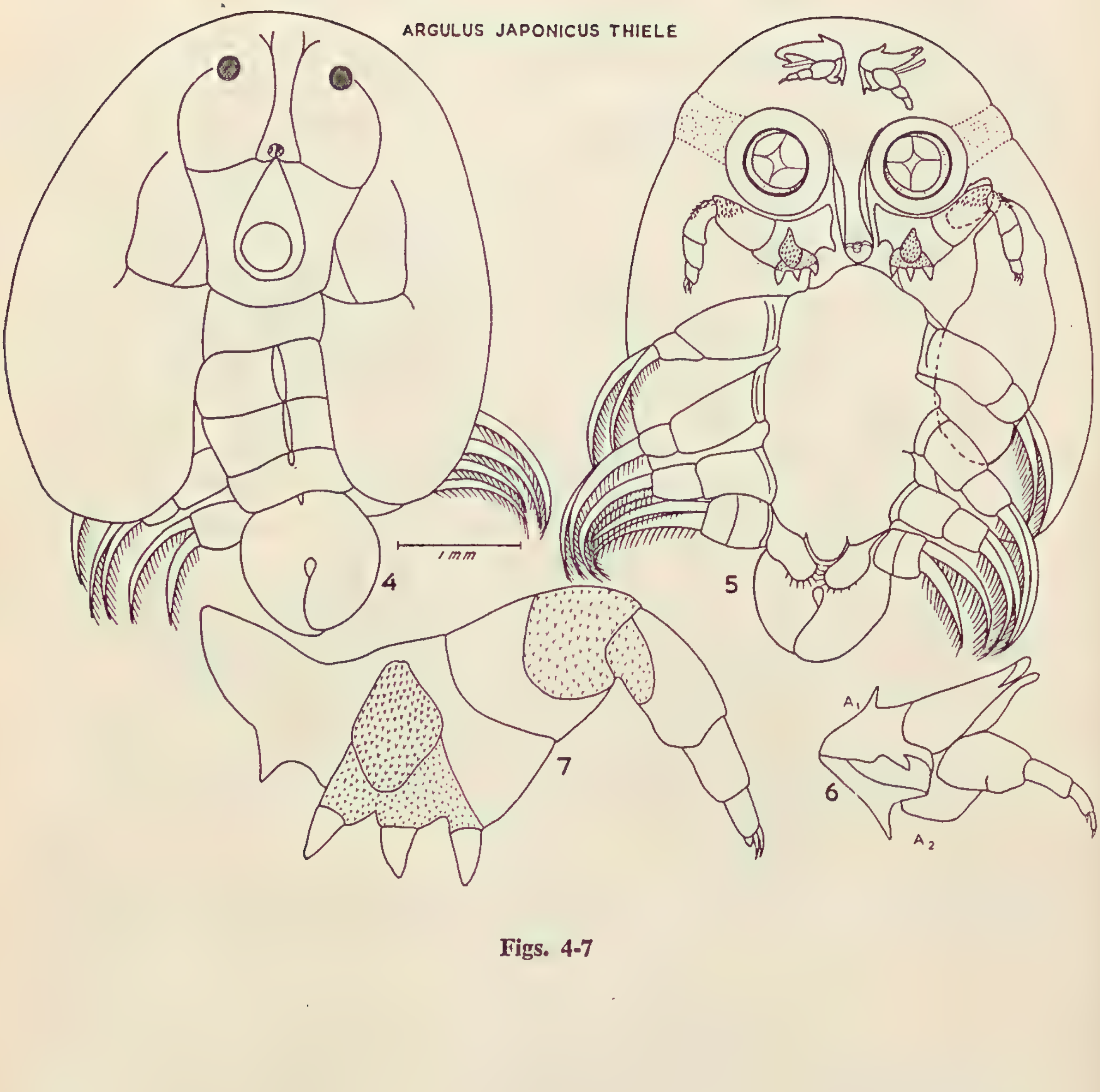
Figs. 237-245. *Brachiella cirrata* sp. n. Fig. 237, female. Fig. 238, frontal part of head from ventral. Fig. 239, detail of second maxilla. Fig. 240, posterior part of trunk, with genital process and posterior processes from dorsal. Fig. 241, male from lateral. Fig. 242, first antenna of male. Fig. 243, second antenna of male. Fig. 244, maxilla of male. Fig. 245, maxilliped of male.

Figs. 246-250. *Brachiella stellifera* sp. n. Fig. 246, female. Fig. 247, frontal part of head from ventral. Fig. 248, detail of second maxilla with bulla and maxillary gland. Fig. 249, male. Fig. 250, frontal part of head of male.

Sydney: V. C. N. Blight, Government Printer—1962

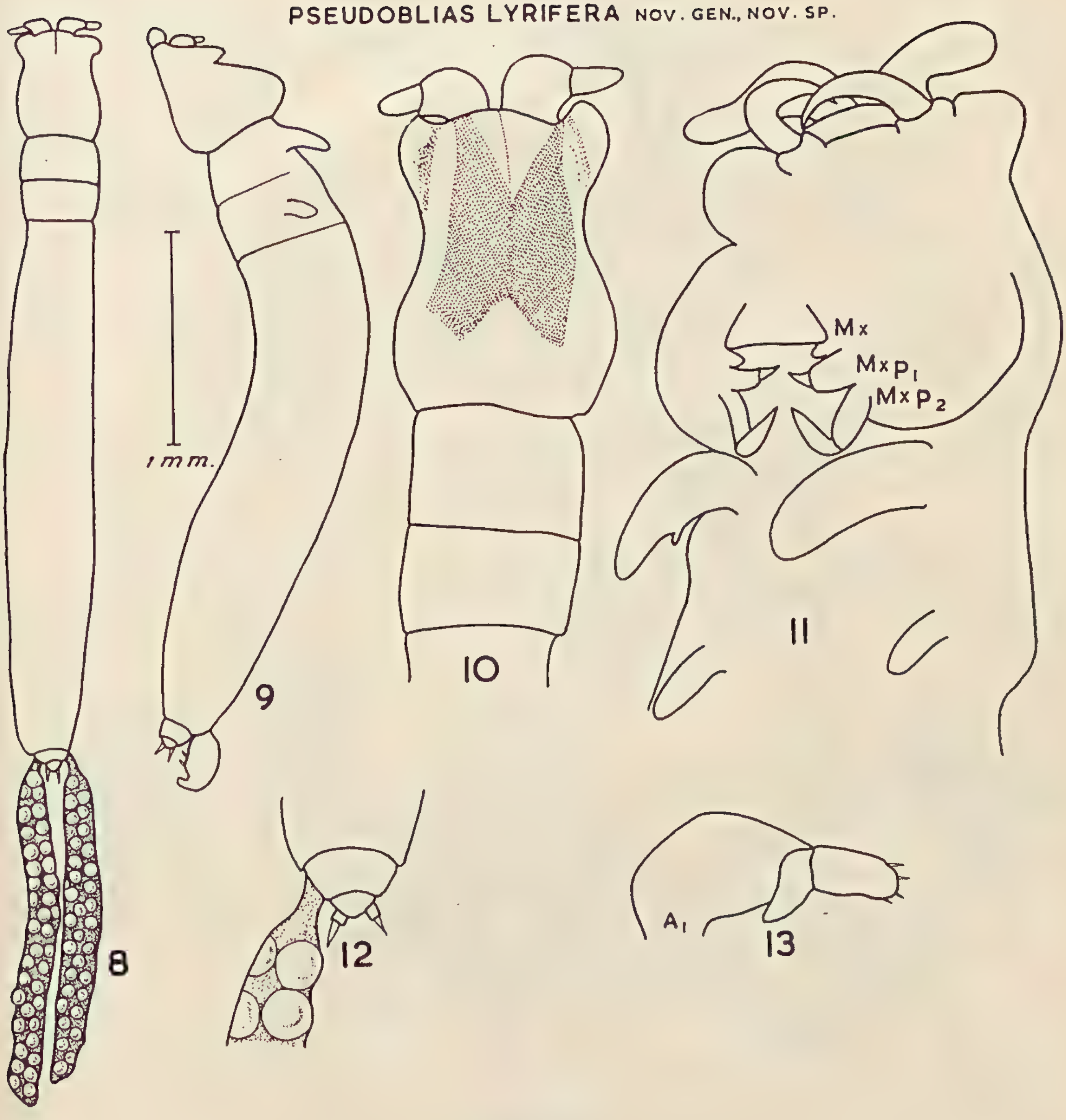


Figs. 1-3

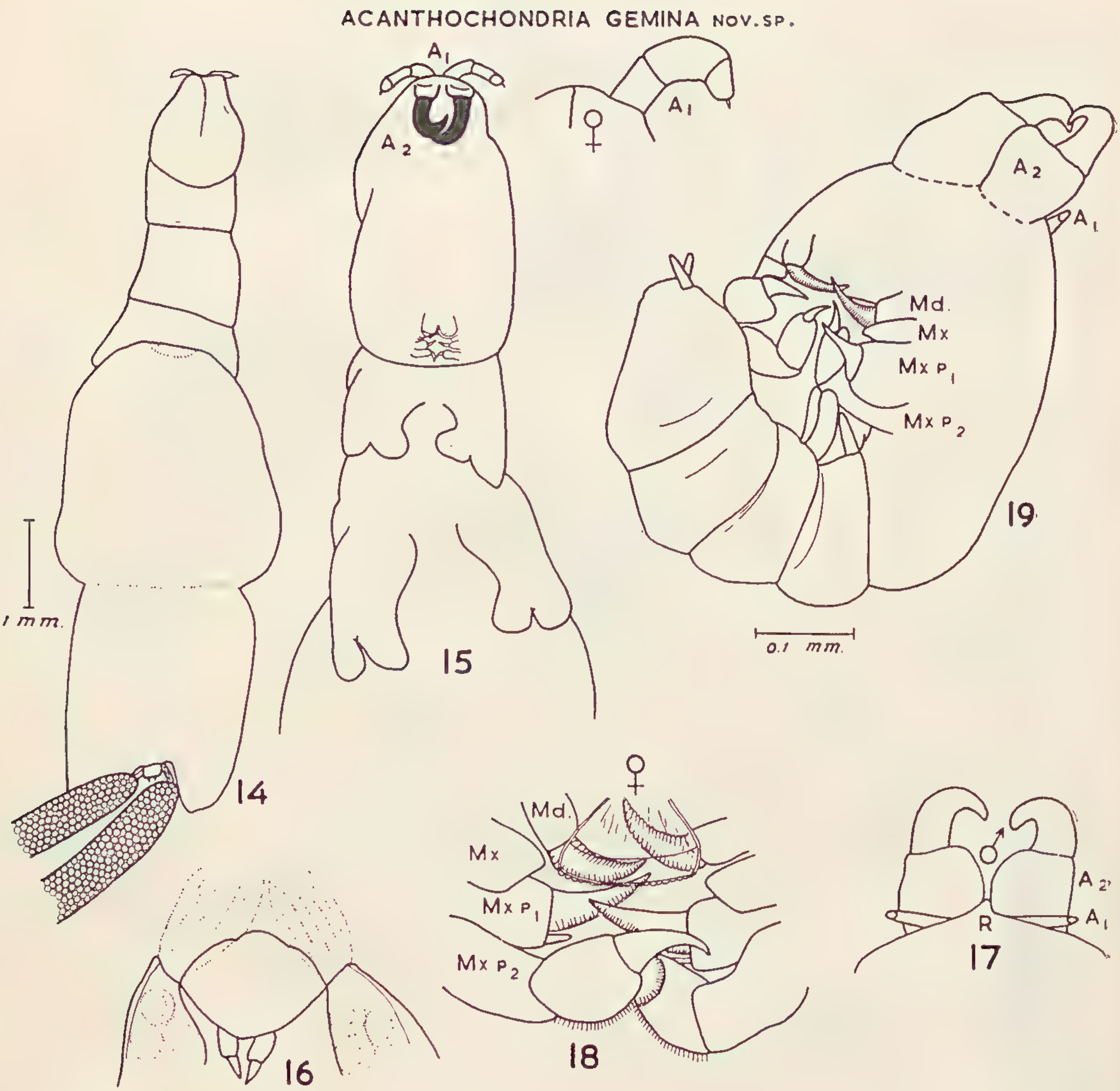


Figs. 4-7

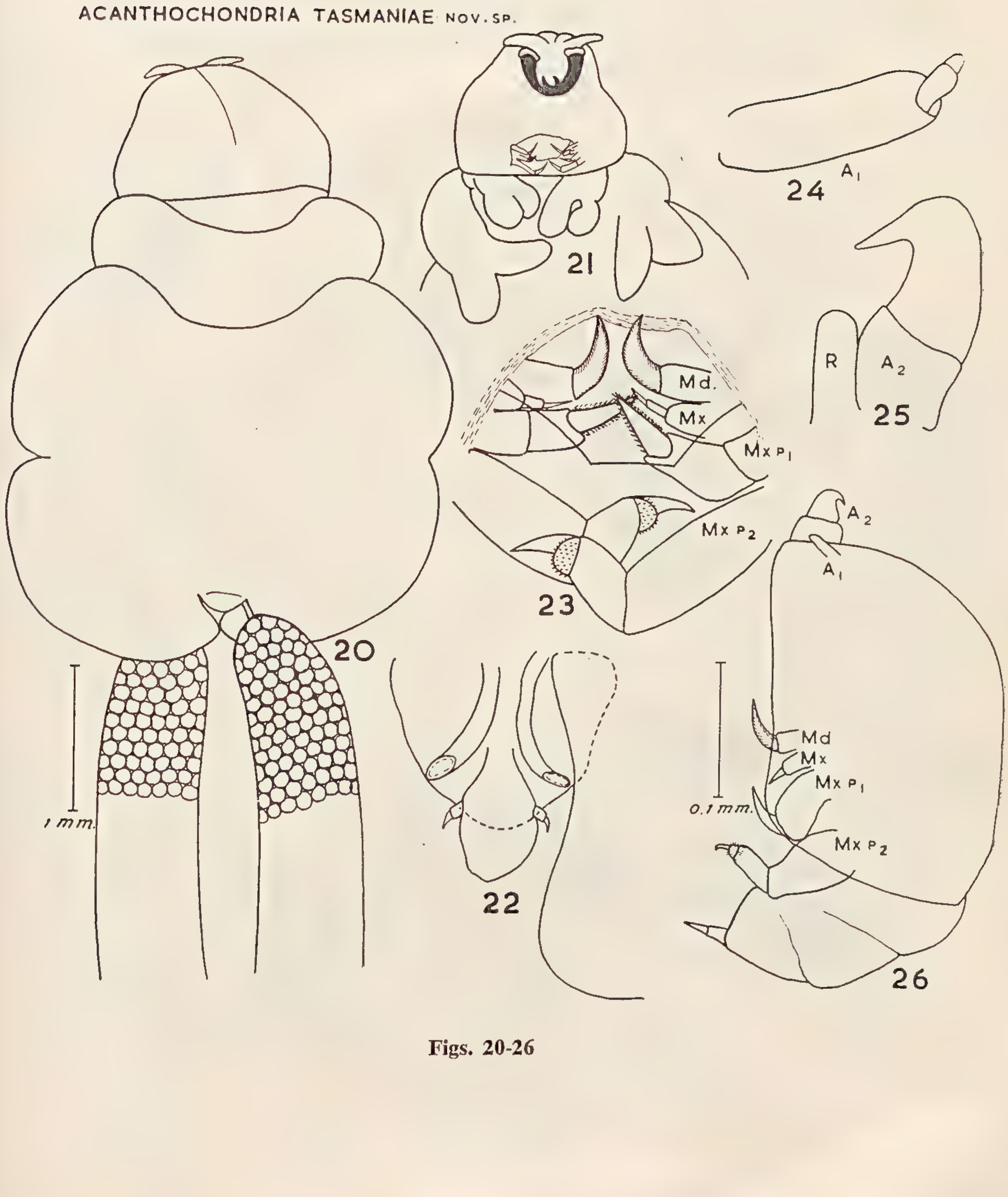
PSEUDOBLIAS LYRIFERA NOV. GEN., NOV. SP.



Figs. 8-13

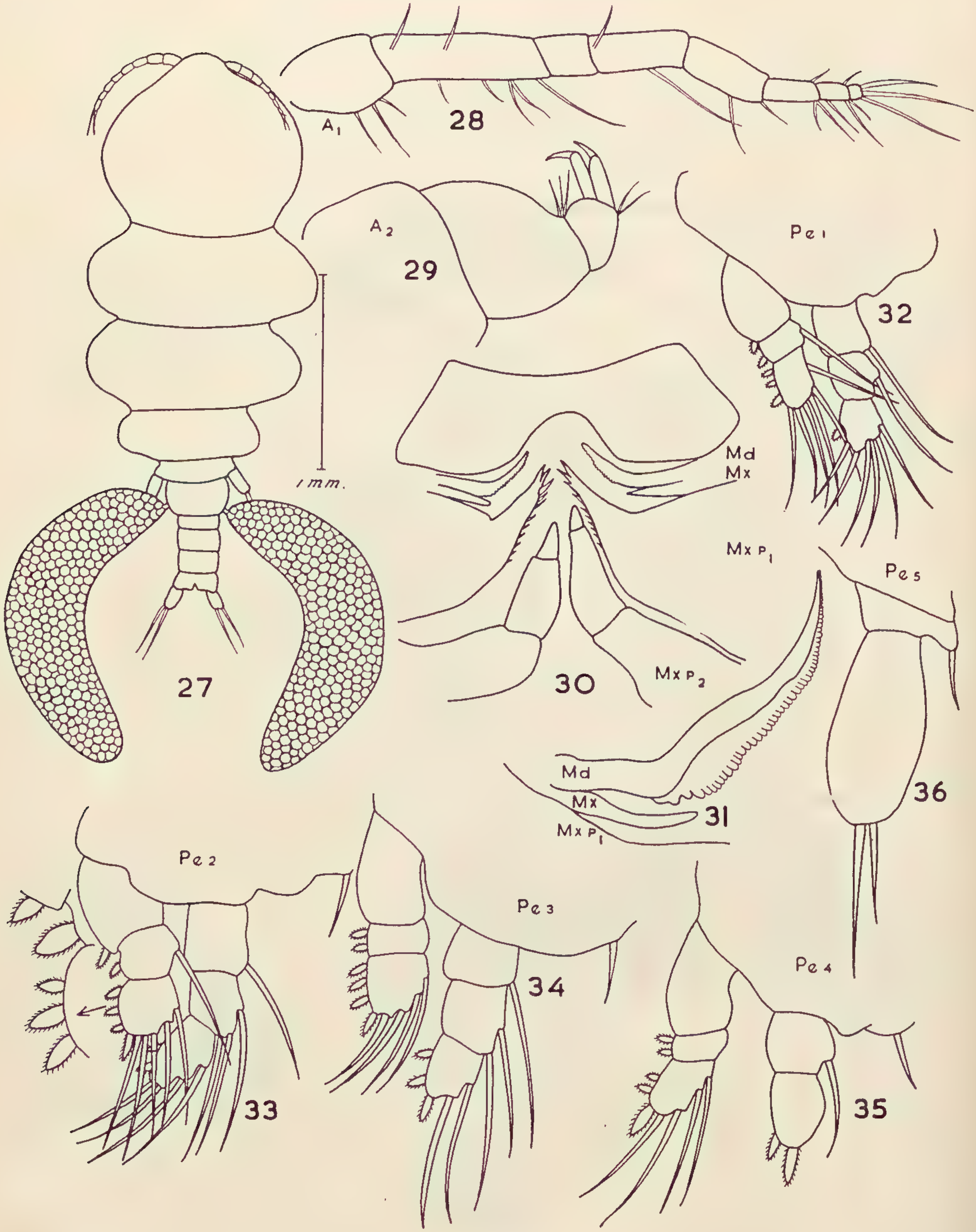

ACANTHOCHONDRIA GEMINA NOV. SP.
A1
A2
♀
A1
A2
A1
Md.
Mx
Mx P1
Mx P2
19
1 mm.
15
0.1 mm.
14
♀
Md.
Mx
Mx P1
Mx P2
18
16
♂
A2
R
A1
17

Figs. 14-19

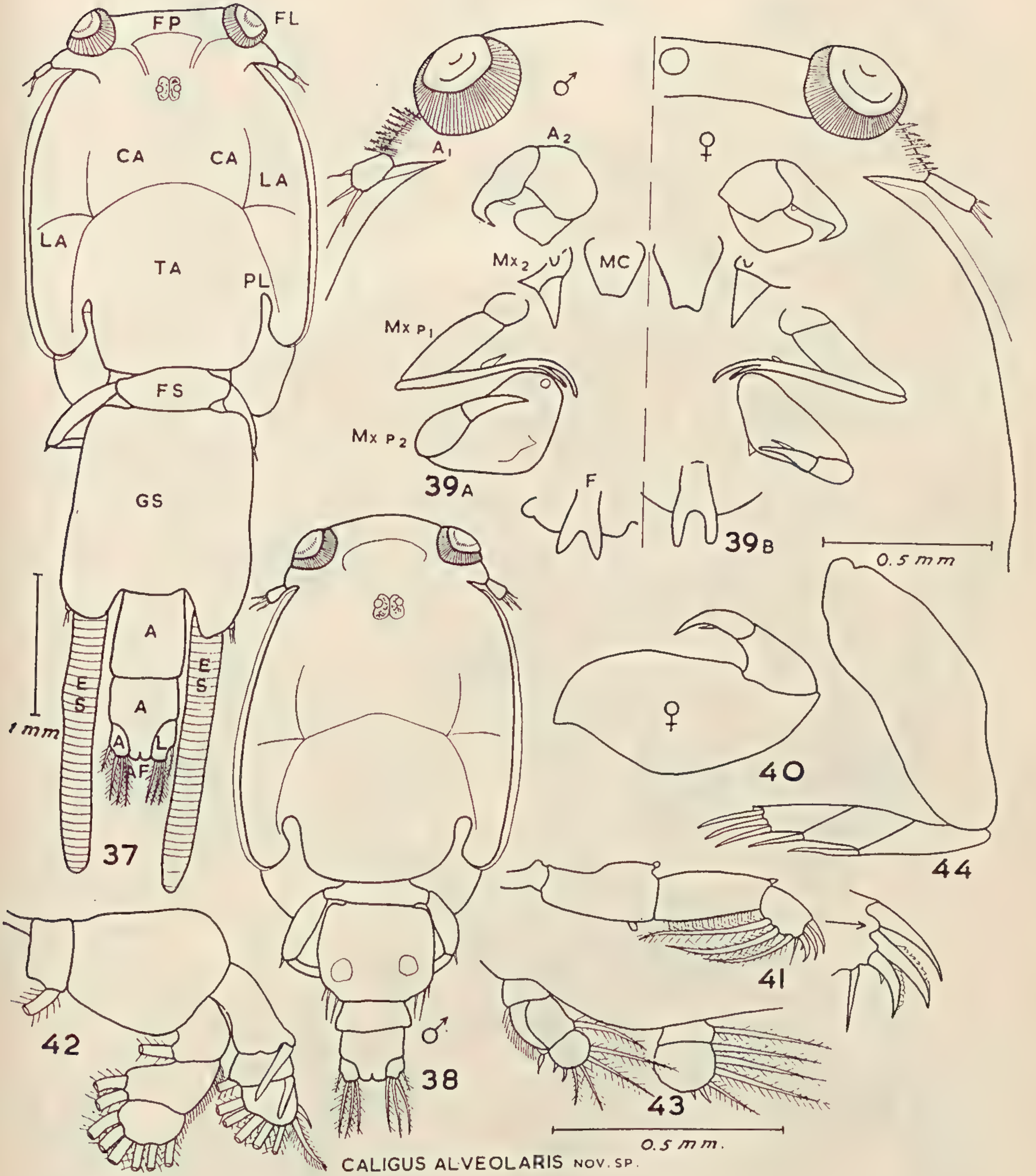

ACANTHOCHONDRIA TASMANIAE NOV. SP.
20
21
22
23
24
25
26
A1
R
A2
Md.
Mx
Mx P1
Mx P2
Md
1 mm.
0.1 mm.

Figs. 20-26

ALIMEDA ORIENTALIS NOV. GEN. ET. SP.



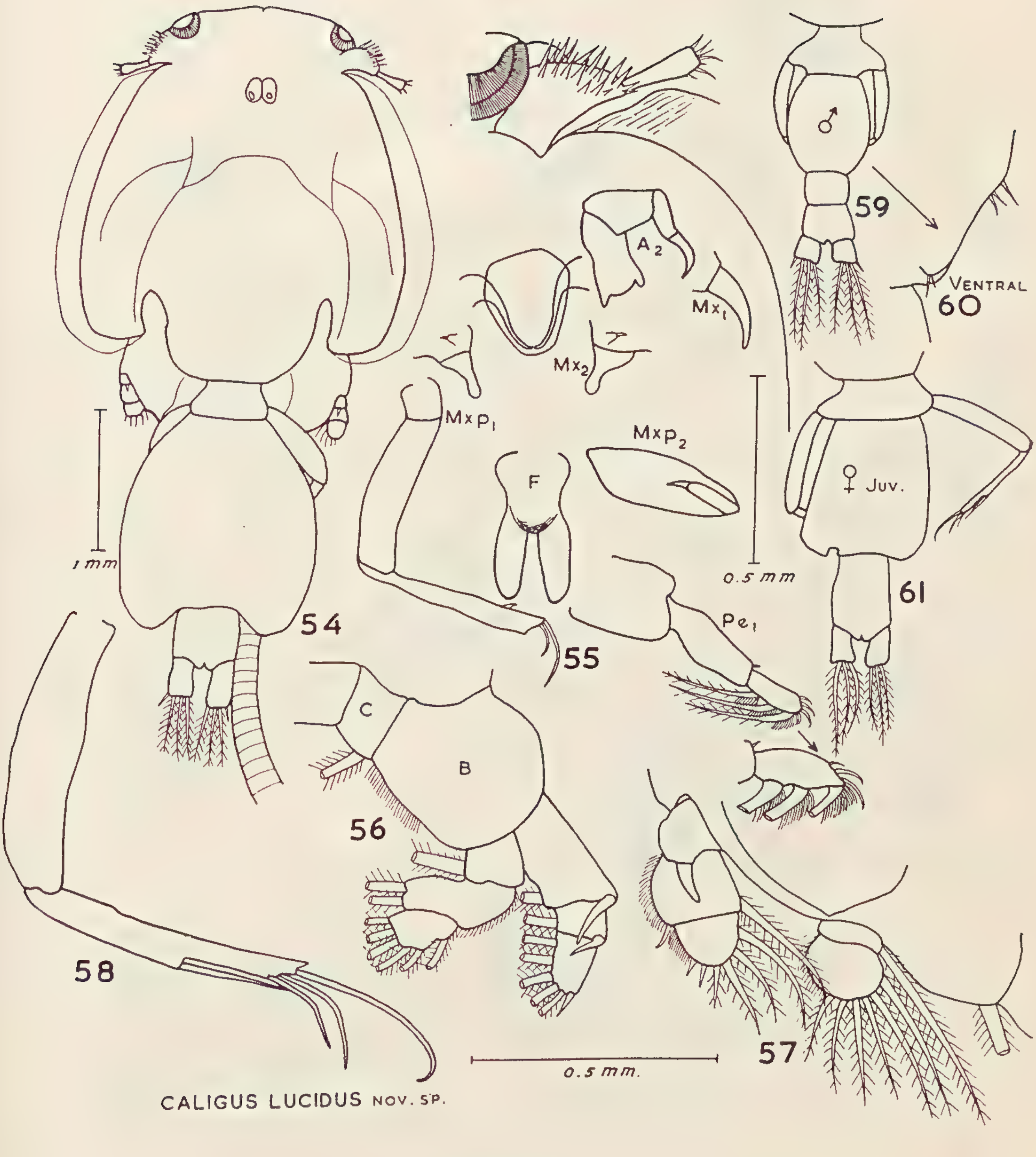
Figs. 27-36


FP
FL
CA
CA
LA
LA
TA
PL
FS
GS
A
A
ES
ES
A
L
AF
1 mm
37
A1
A2
♂
♀
Mx2
MC
Mx P1
Mx P2
39A
F
39B
0.5 mm
40
44
41
42
38
43
0.5 mm.
CALIGUS ALVEOLARIS NOV. SP.

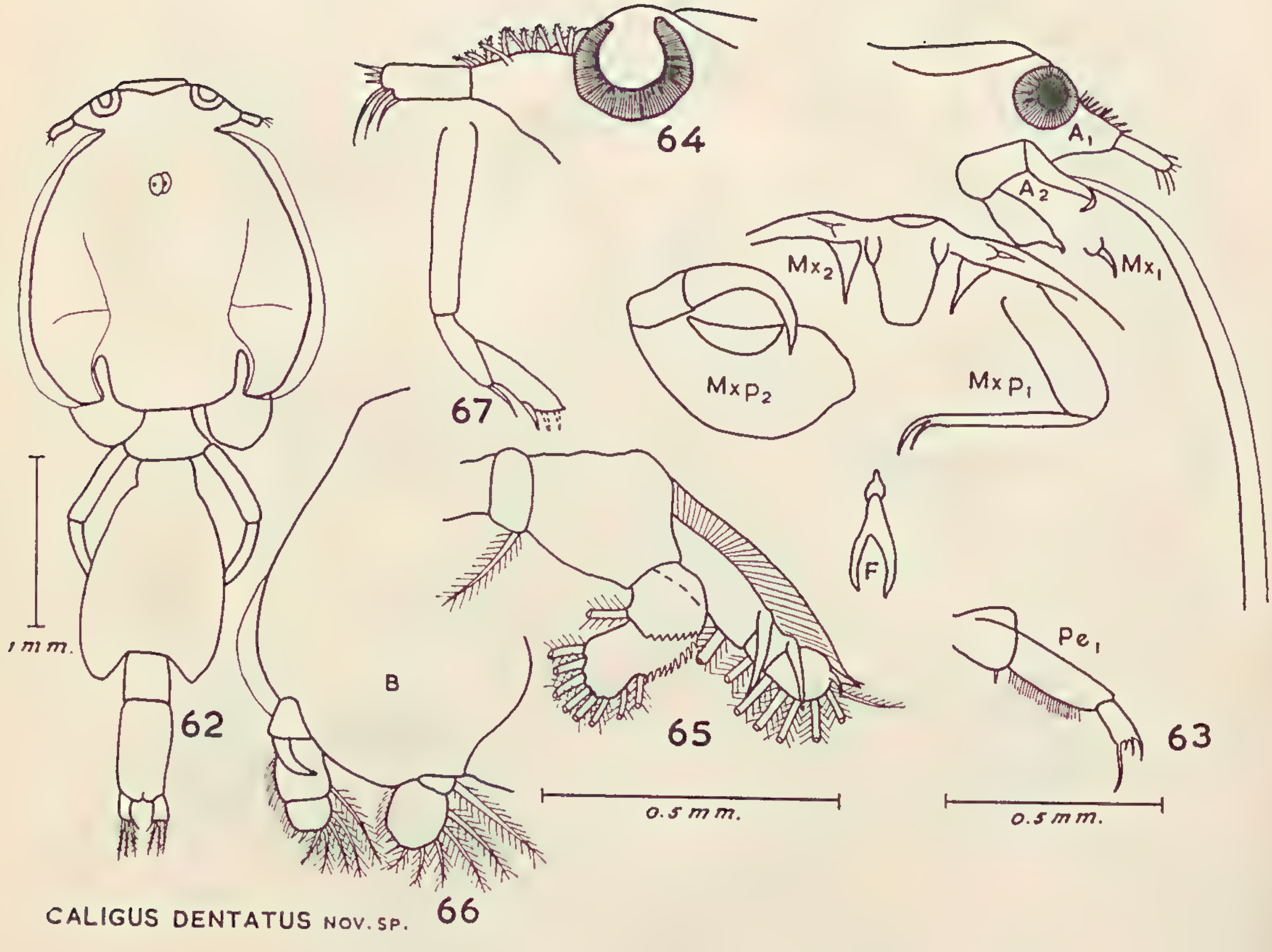
Figs. 37-44

CALIGUS MACULATUS NOV. SP.

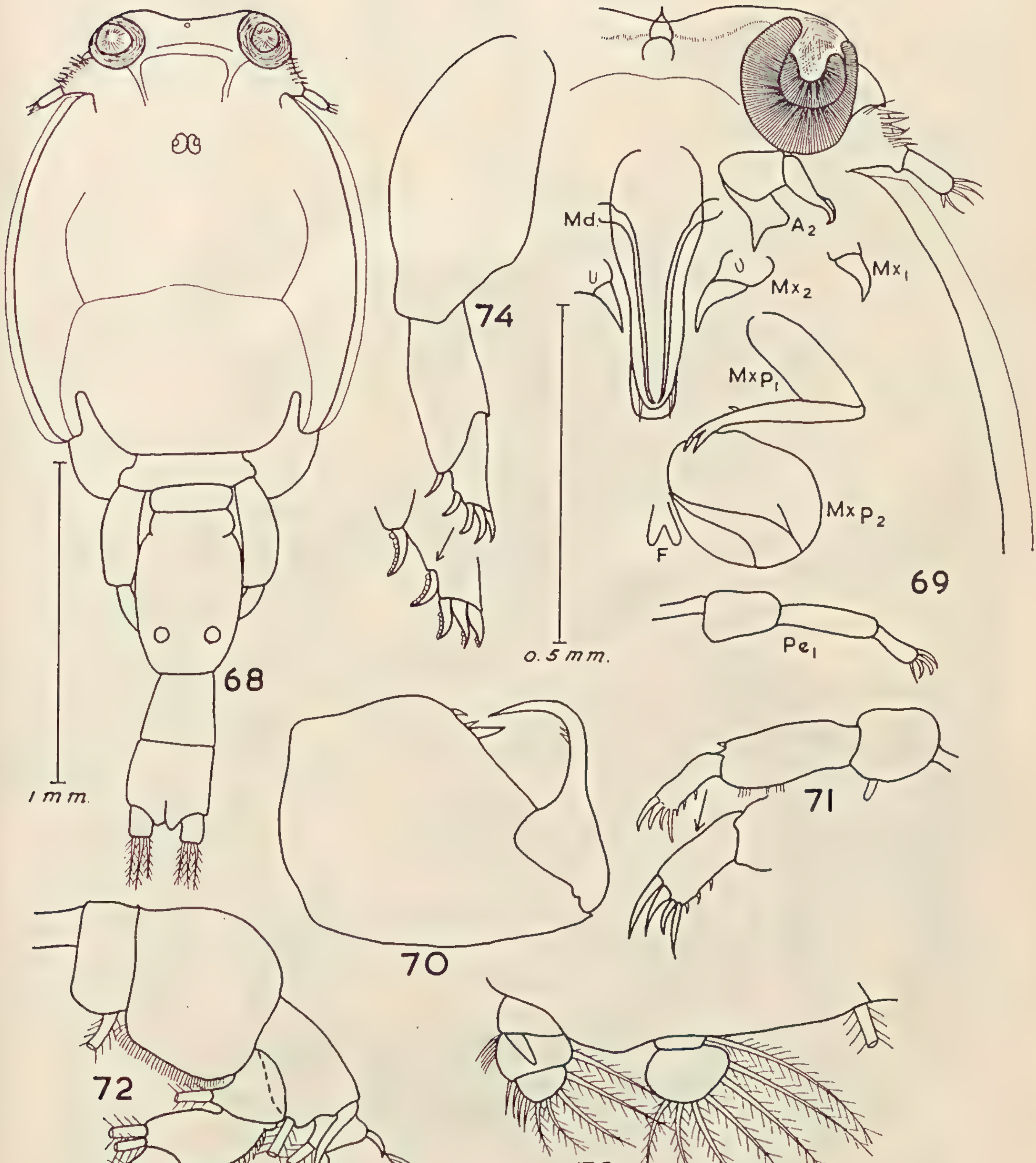
Figs. 45-53


Mxp1
A2
Mx1
Mx2
Mxp2
F
♂
59
Ventral
60
♀ Juv.
61
1 mm
0.5 mm
54
55
Pe1
C
B
56
58
57
0.5 mm.
CALIGUS LUCIDUS NOV. SP.

Figs. 54-61

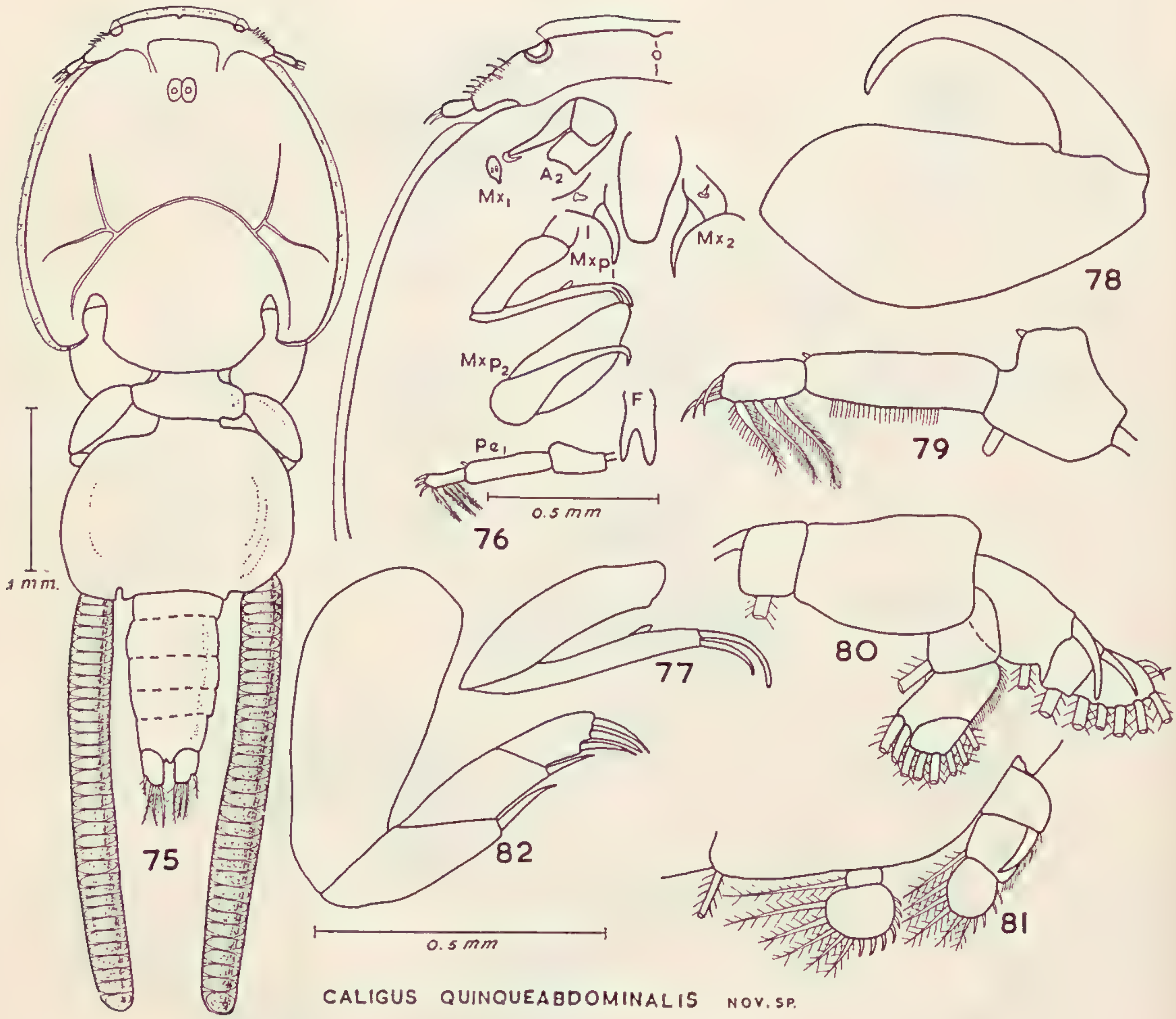

64
A1
A2
Mx2
Mx1
Mxp2
Mxp1
67
F
Pe1
1 mm.
B
65
63
62
0.5 mm.
0.5 mm.
CALIGUS DENTATUS NOV. SP.
66

Figs. 62-67

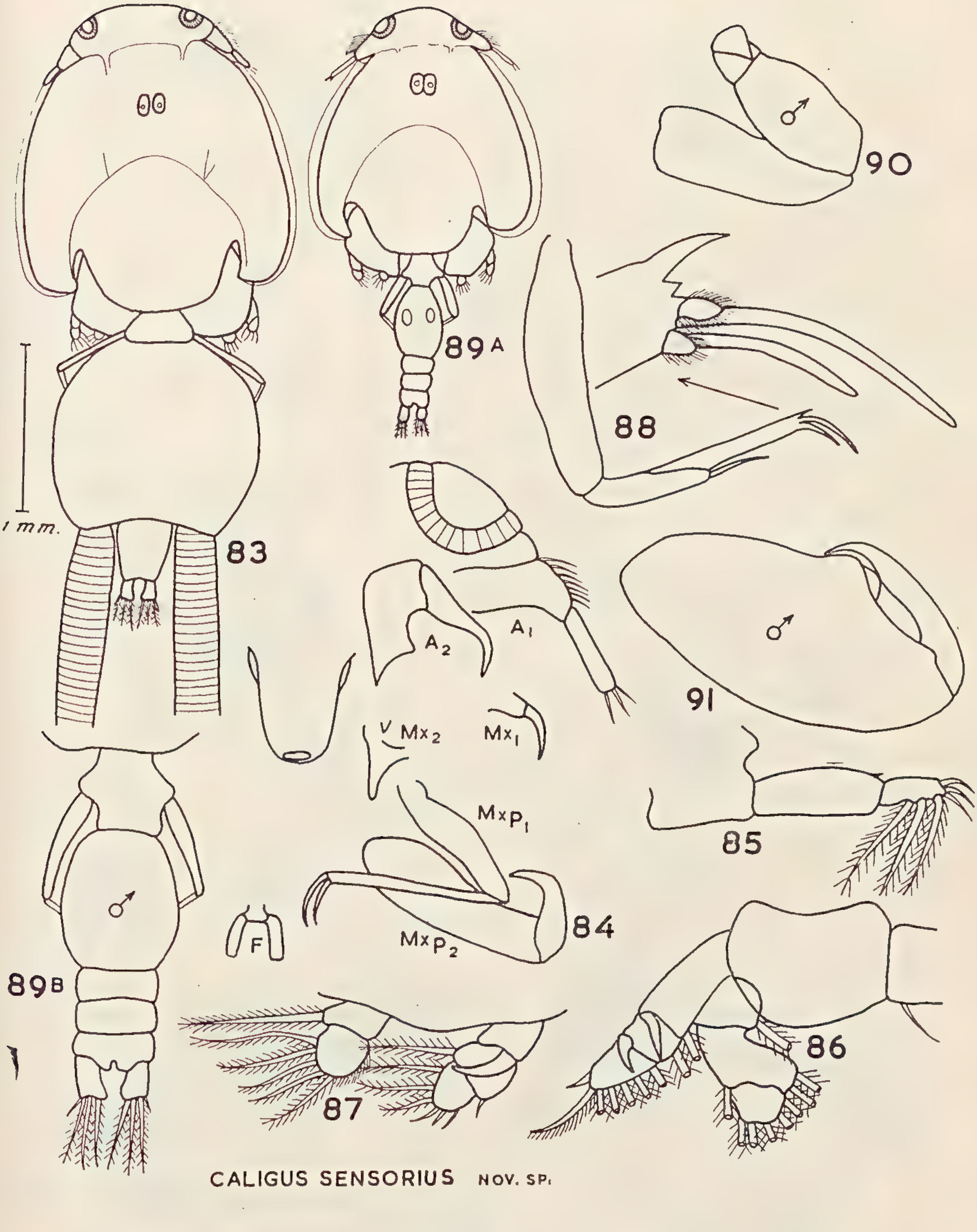


CALIGUS PROBOSCIDATUS NOV. SP.

Figs. 68-74

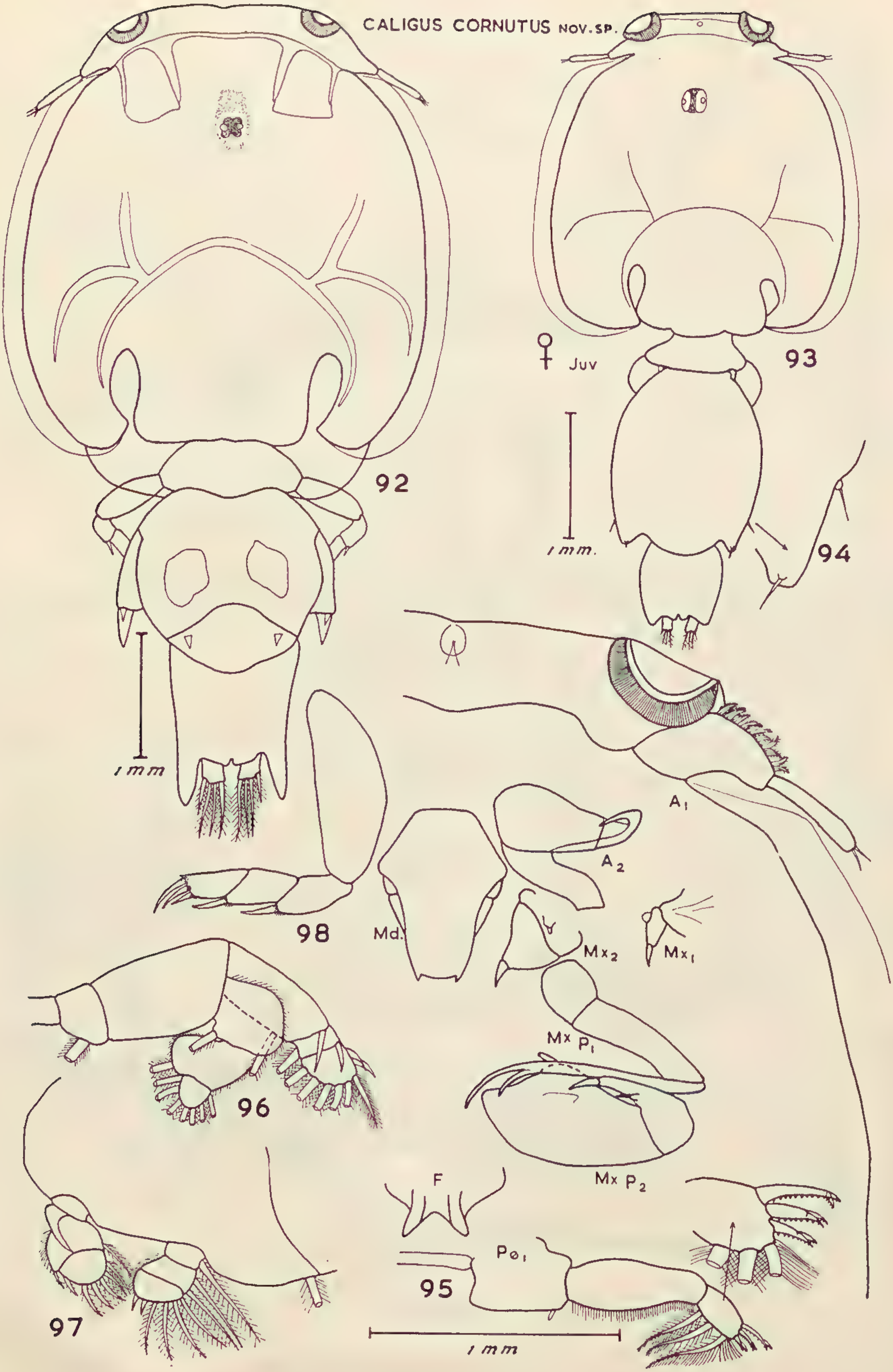

Mx1
A2
Mx2
I
Mxp1
Mxp2
F
Pe1
0.5 mm
1 mm.
75
76
77
78
79
80
81
82
0.5 mm
CALIGUS QUINQUEABDOMINALIS NOV. SP.

Figs. 75-82

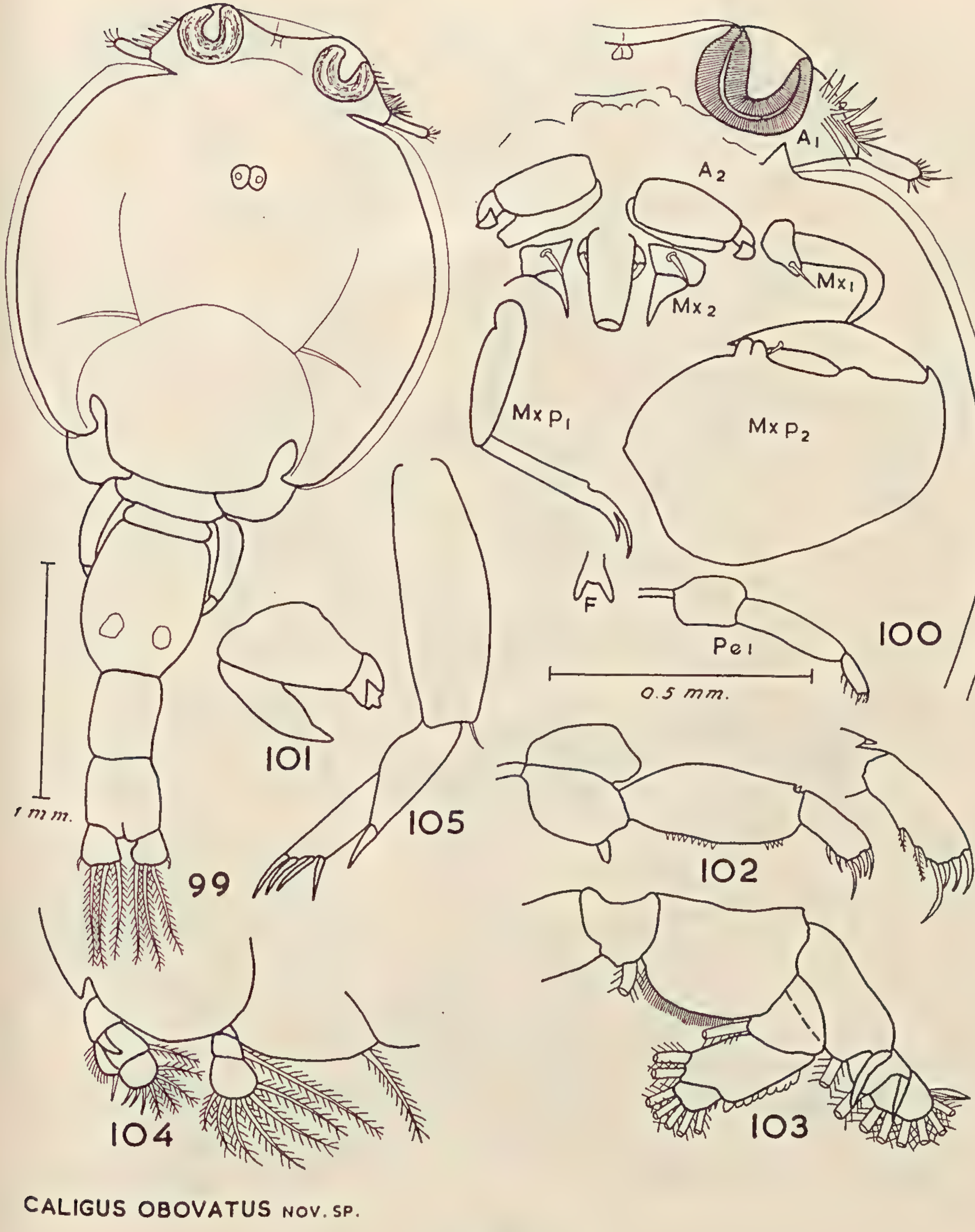


83
84
85
86
87
88
89 A
89 B
90
91
1 mm.
A1
A2
Mx1
V Mx2
MxP1
MxP2
F
CALIGUS SENSORIUS NOV. SP.

Figs. 83-91

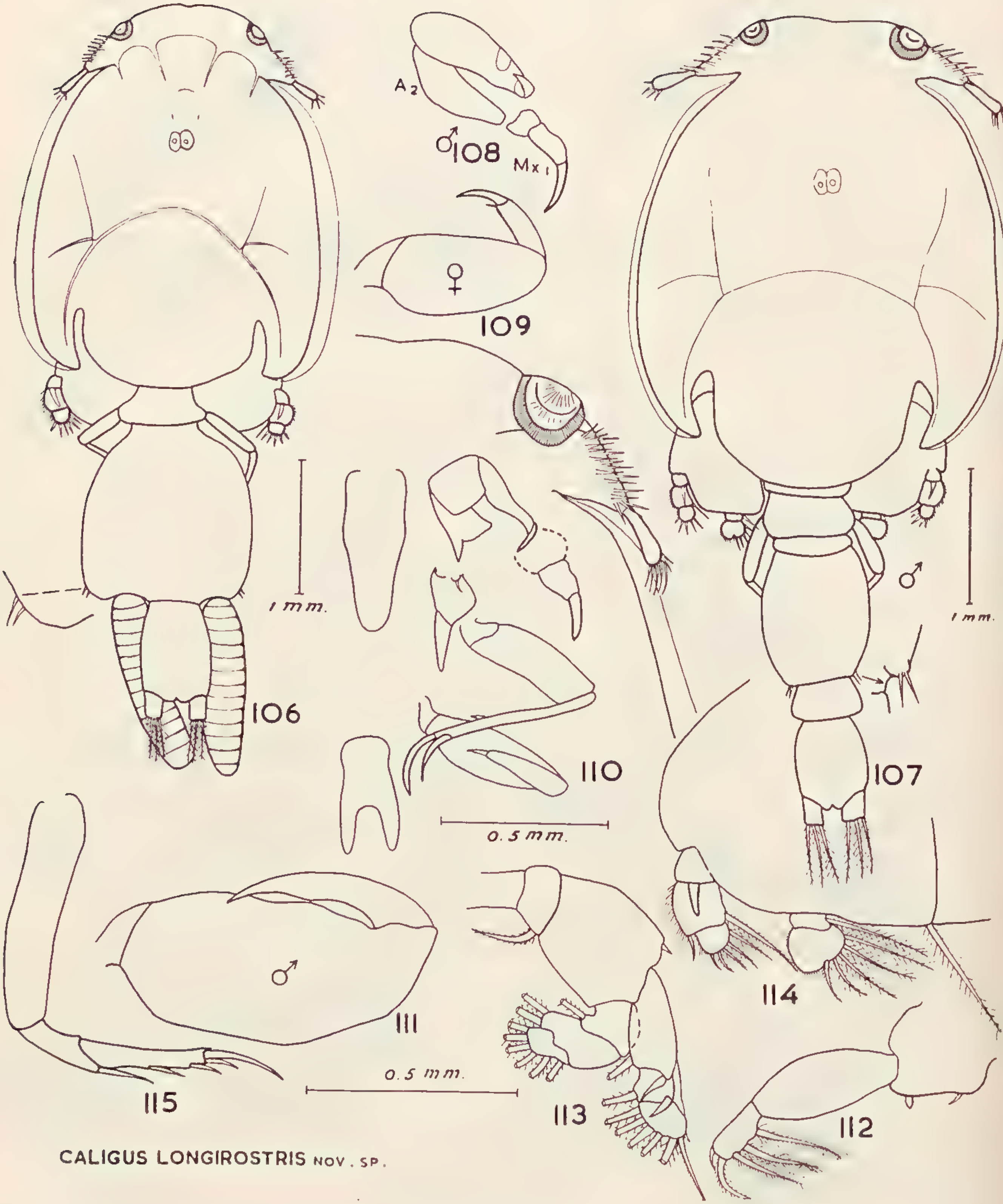

CALIGUS CORNUTUS NOV. SP.
92
93
♀ Juv
94
1 mm
1 mm.
1 mm
A1
A2
Md.
Mx2
Mx1
Mx P1
Mx P2
98
96
97
F
Po1
95
1 mm

Figs. 92-98

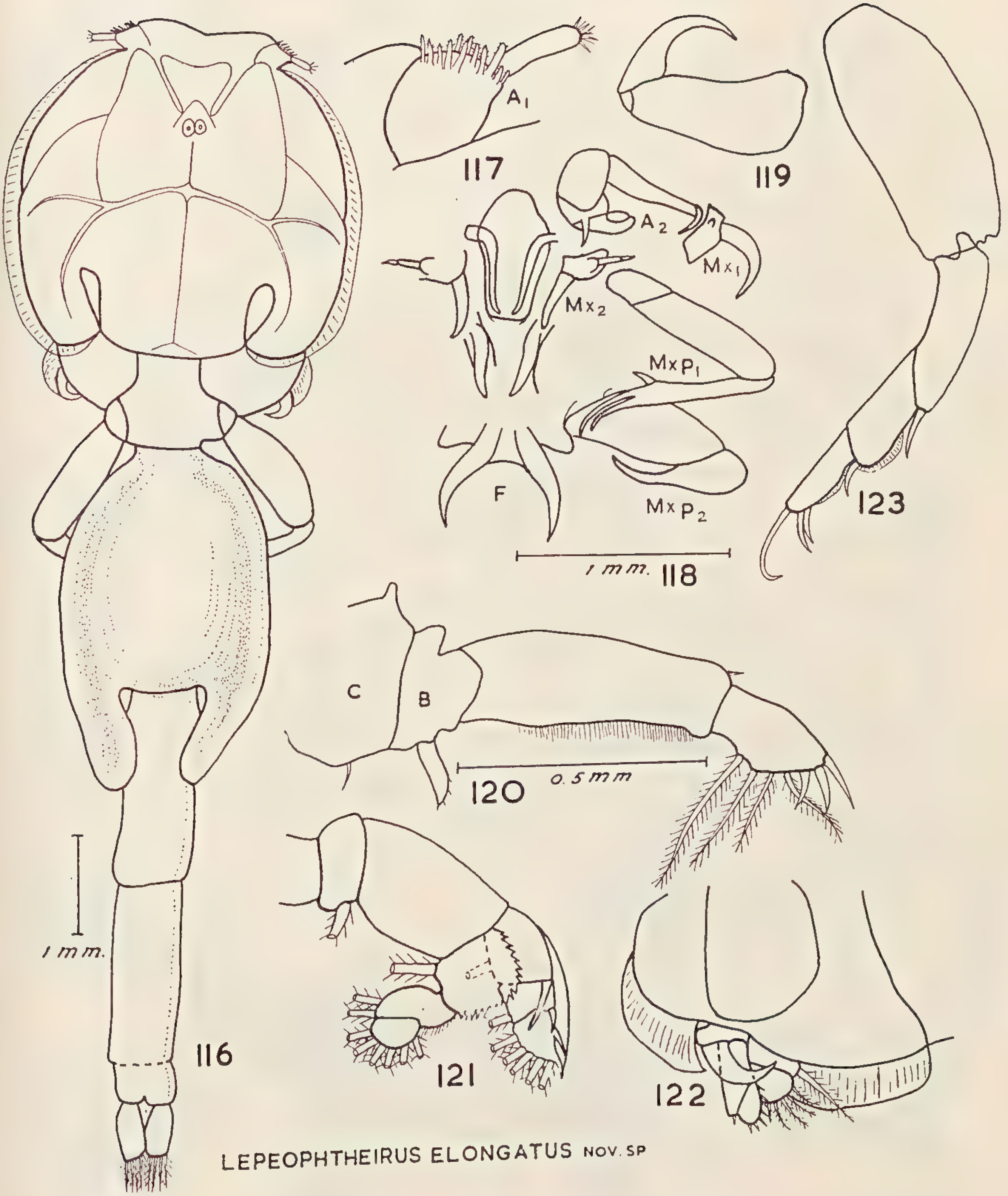


CALIGUS OBOVATUS NOV. SP.

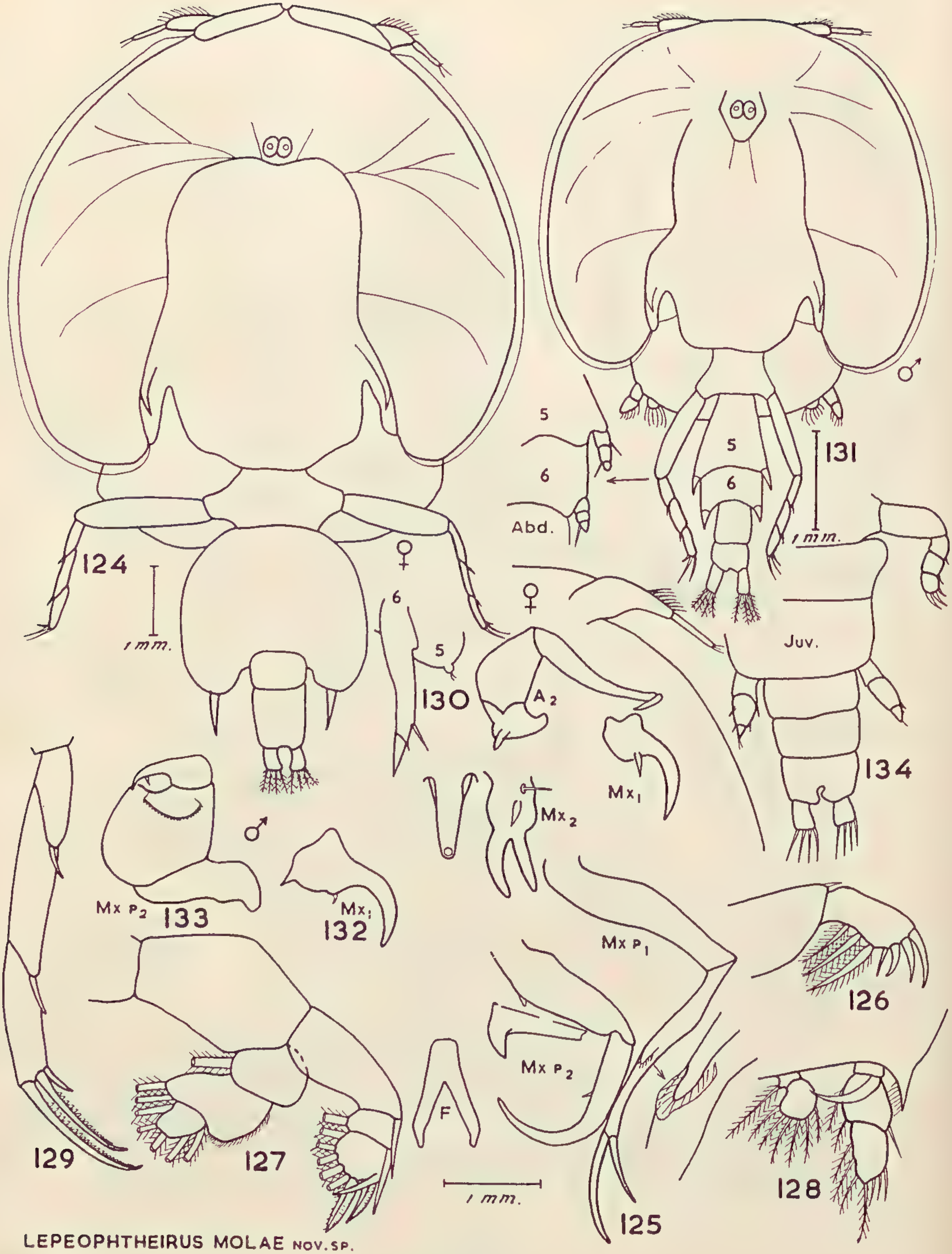
Figs. 99-105


A2
♂108
Mx1
♀
109
1 mm.
106
110
0.5 mm.
♂
1 mm.
107
♂
111
0.5 mm.
114
115
113
112
CALIGUS LONGIROSTRIS NOV. SP.

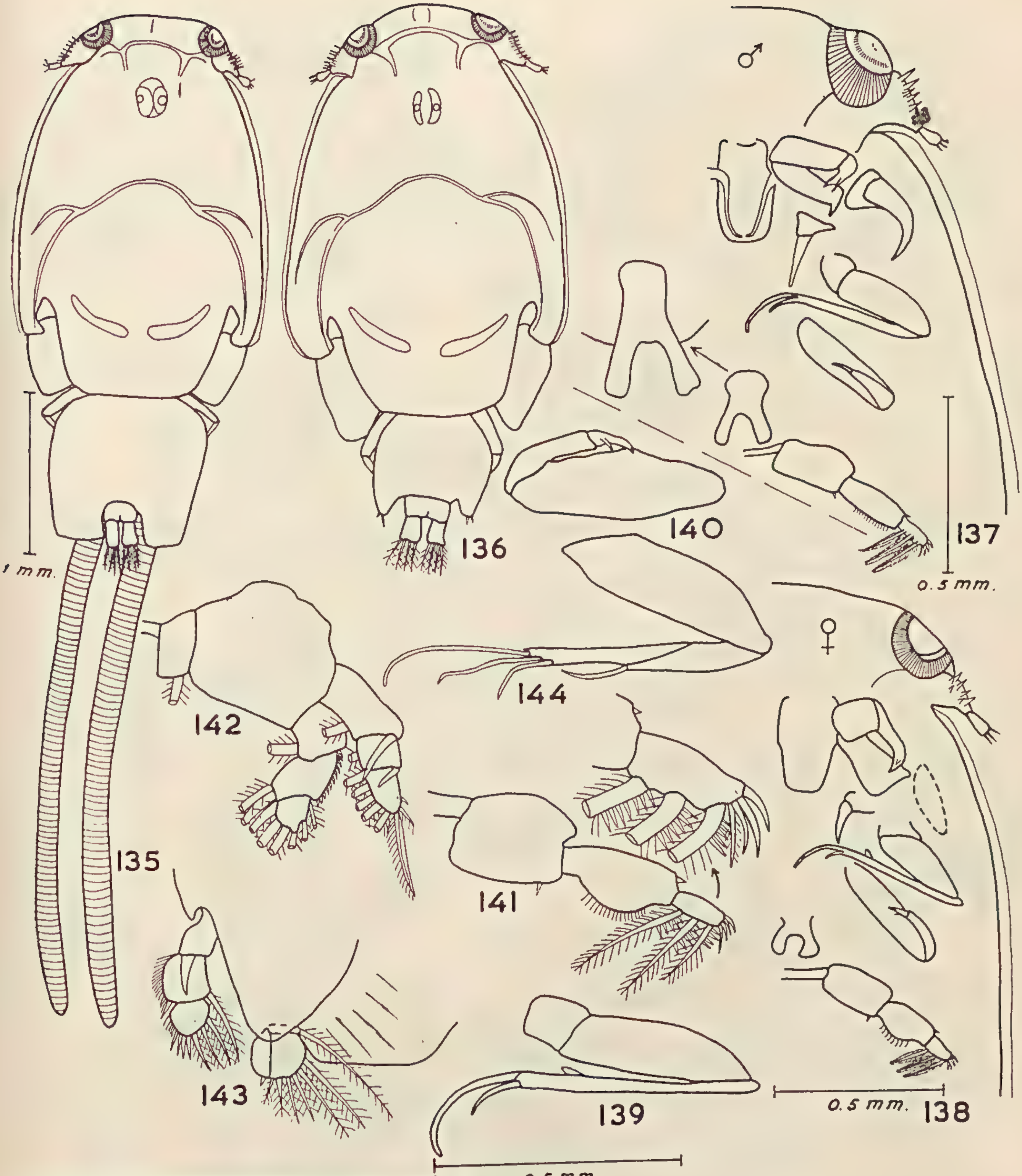
Figs. 106-115


A1
117
119
A2
Mx1
Mx2
MxP1
F
MxP2
123
1 mm.
118
C
B
0.5mm
120
1 mm.
116
121
122
LEPEOPHTHEIRUS ELONGATUS NOV. SP

Figs. 116-123

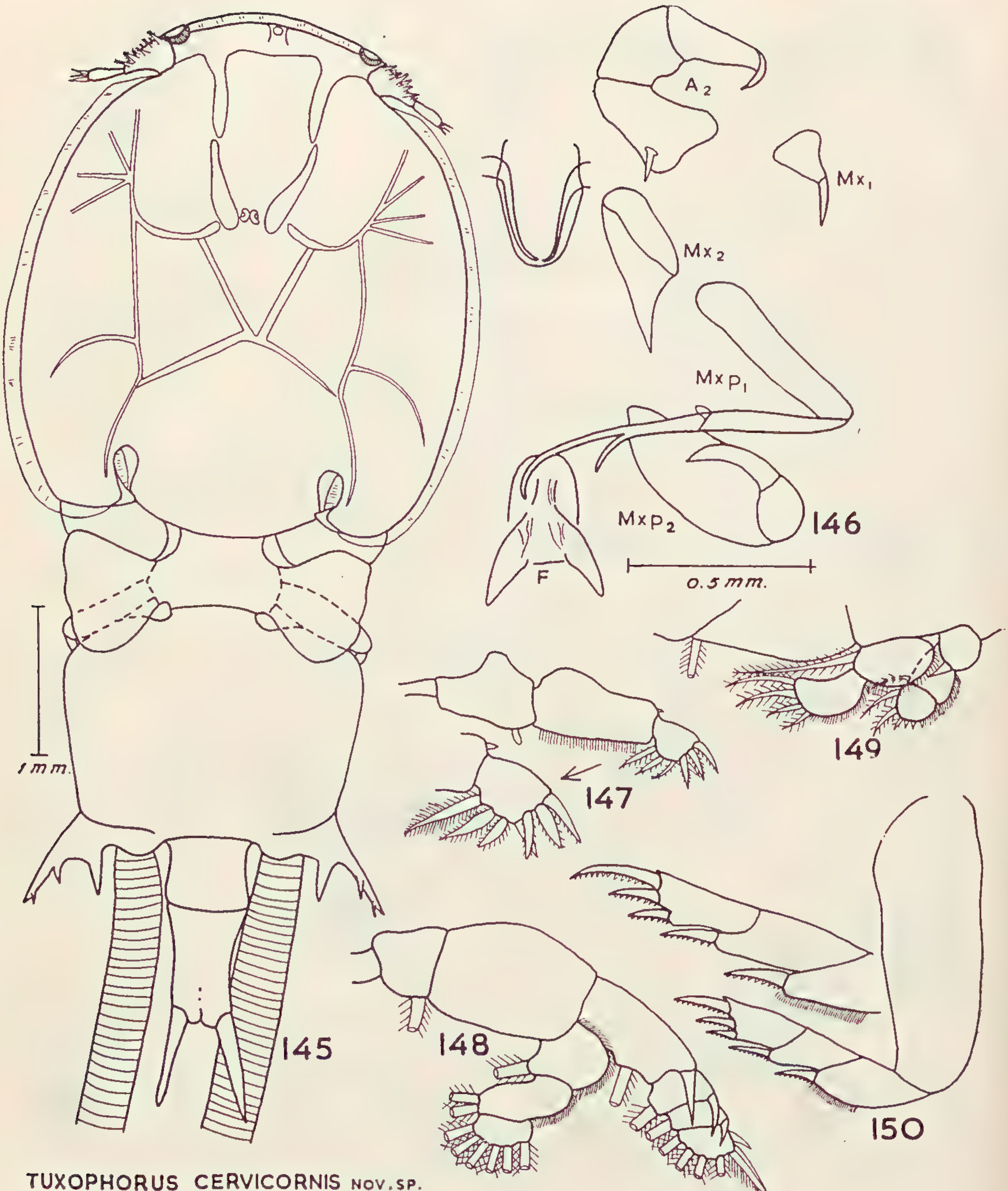

124
1 mm.
♀
6
5
130
131
♂
5
6
Abd.
1 mm.
Juv.
134
A2
Mx1
Mx2
♂
Mx P2
133
Mx1
132
Mx P1
126
Mx P2
F
129
127
128
125
1 mm.
LEPEOPHTHEIRUS MOLAE NOV. SP.

Figs. 124-134



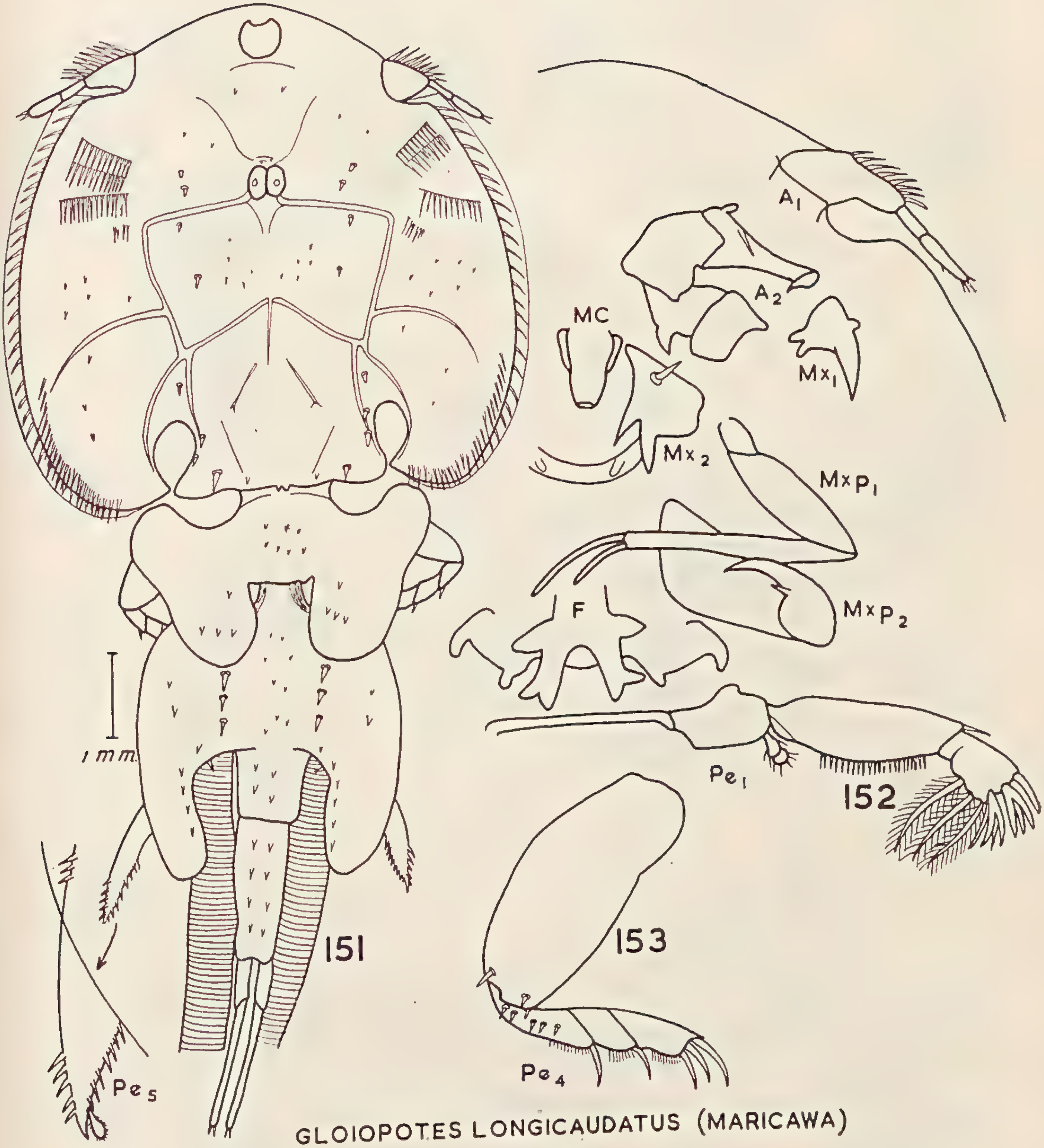
CALIGULUS LONGISPINOSUS NOV. GEN. NOV. SP.

Figs. 135-144



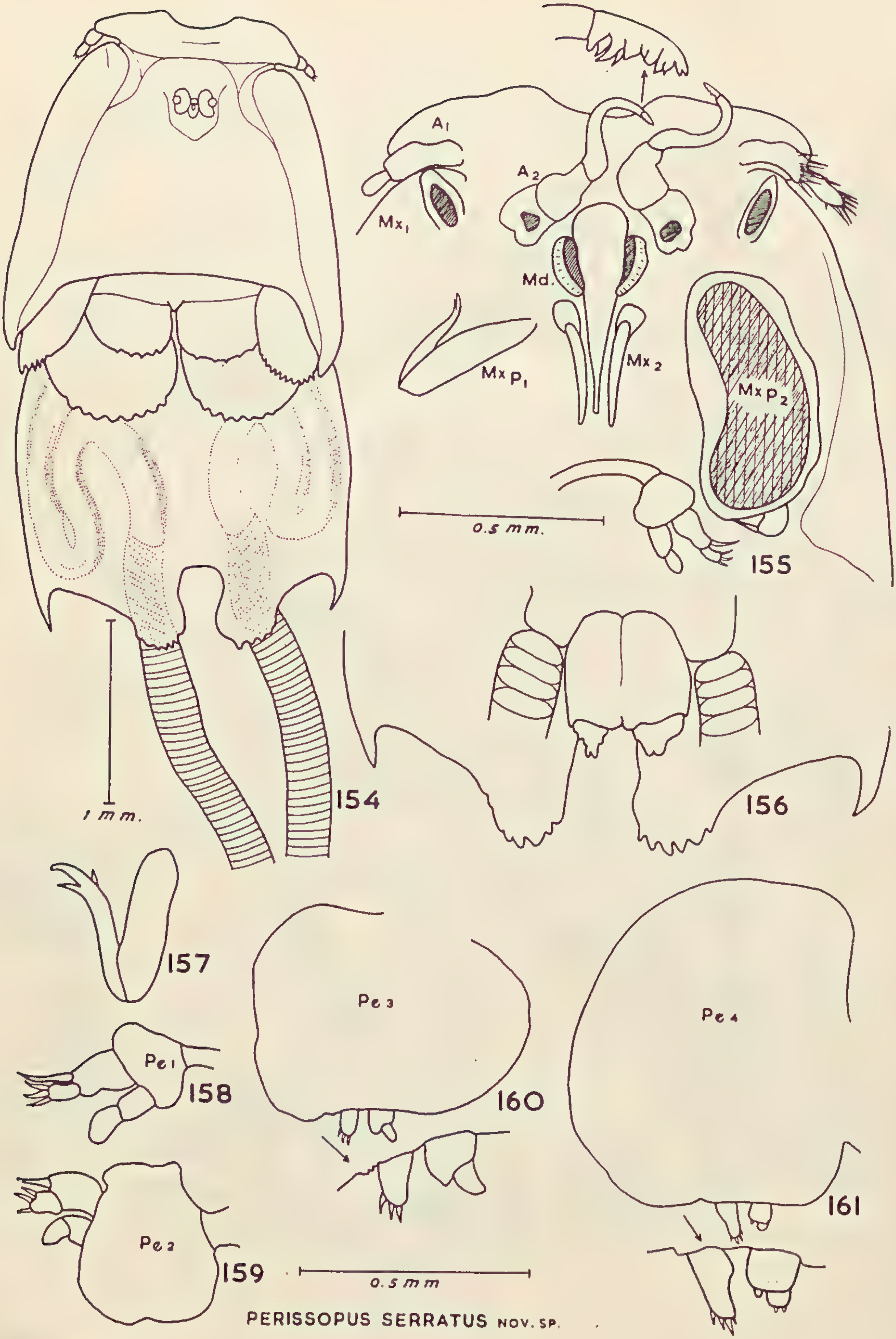
A2
Mx1
Mx2
Mxp1
Mxp2
F
146
0.5 mm.
1 mm.
145
147
148
149
150
TUXOPHORUS CERVICORNIS NOV. SP.

Figs. 145-150



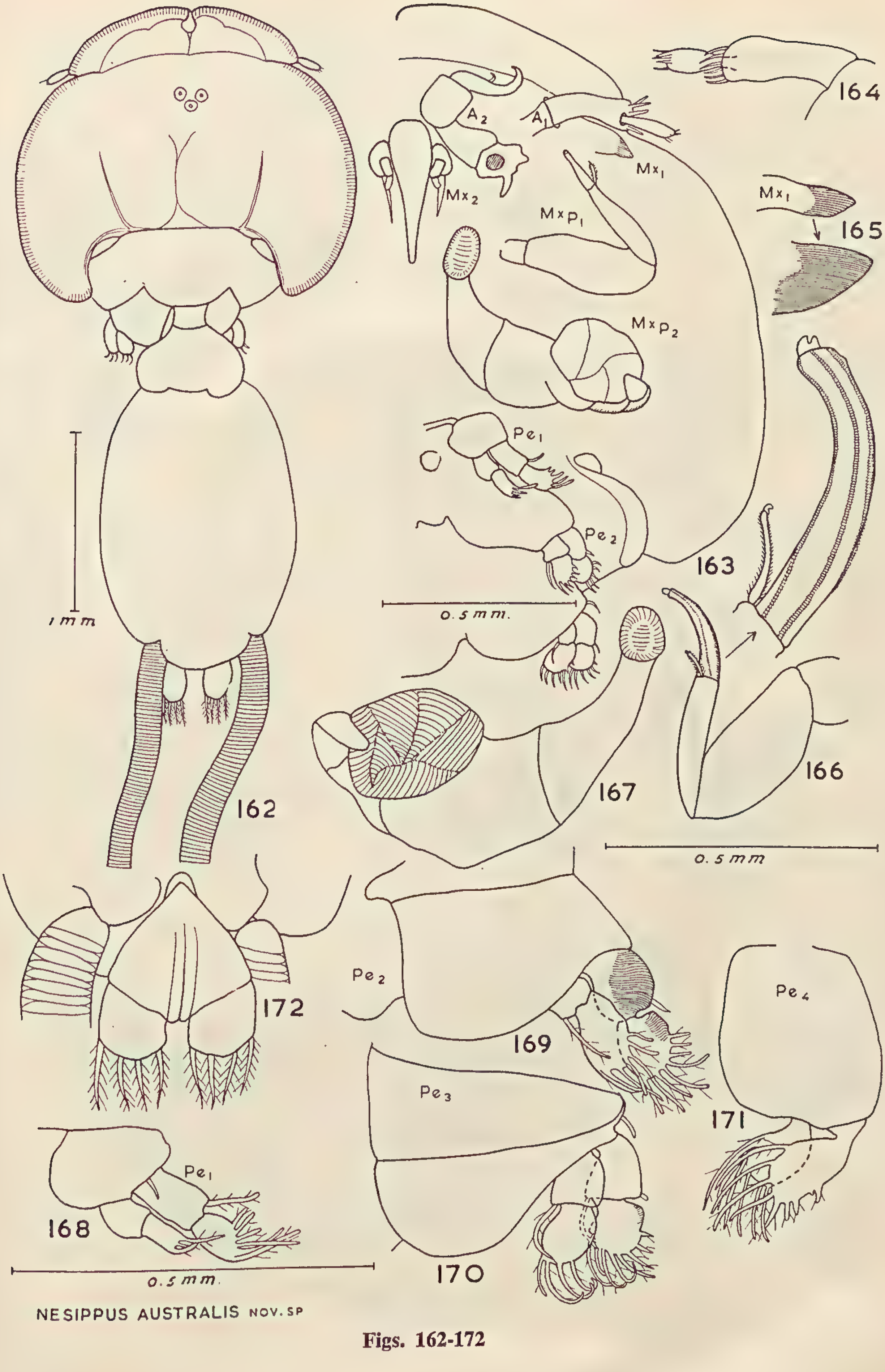
GLOIOPOTES LONGICAUDATUS (MARICAWA)

Figs. 151-153



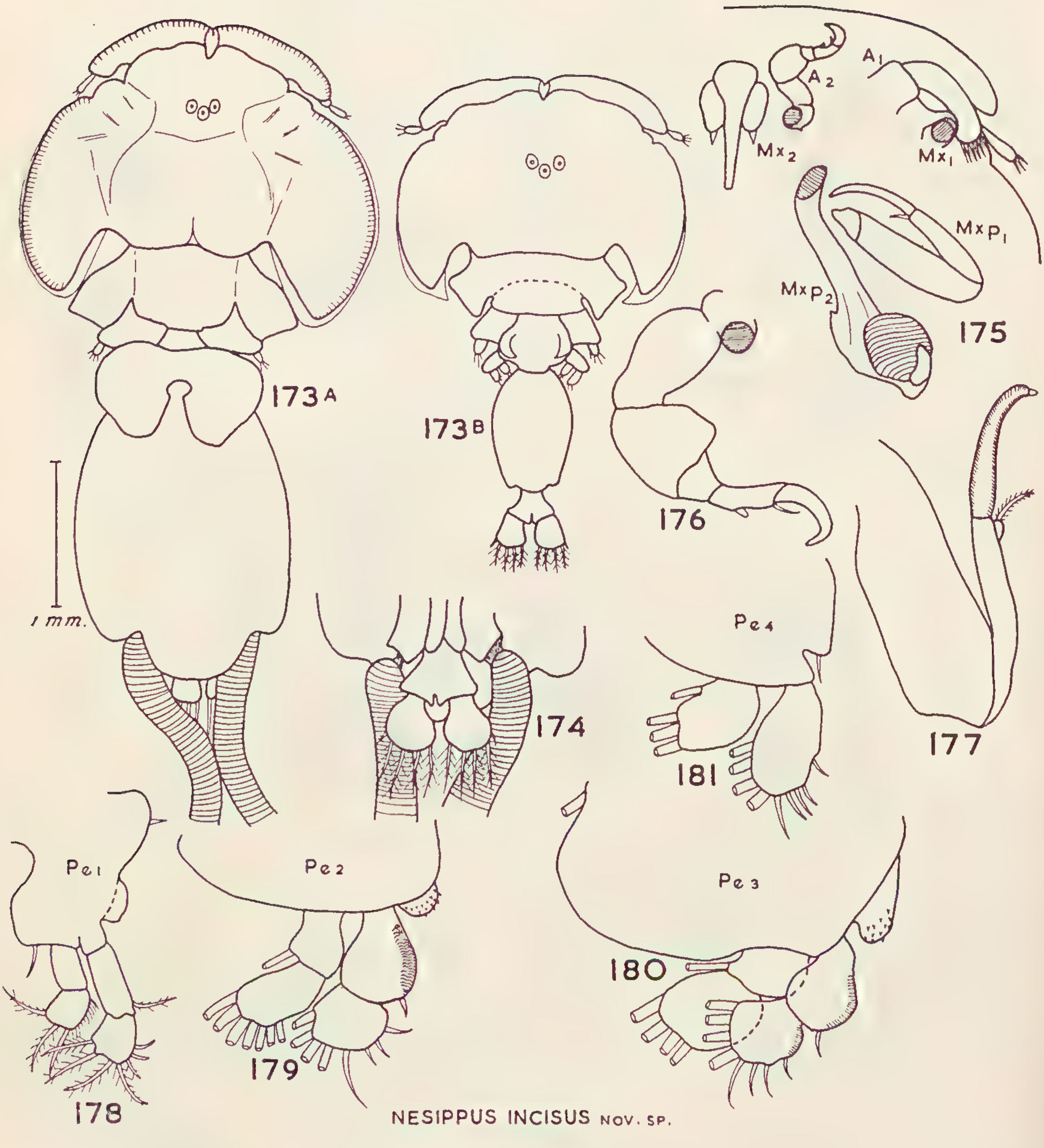
PERISSOPUS SERRATUS NOV. SP.

Figs. 154-161



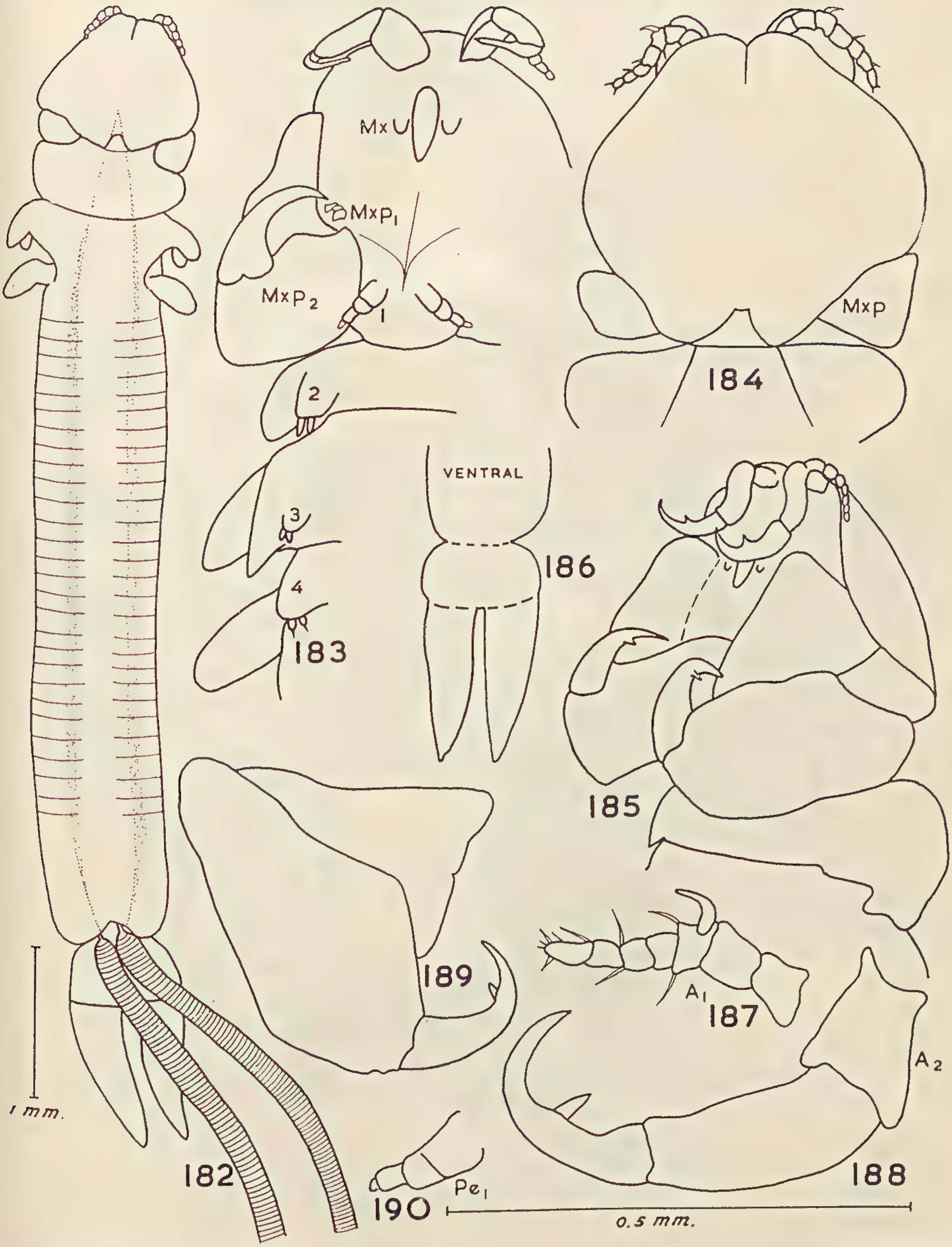
164
Mx_1
165
A_2
A_1
Mx_1
Mx_2
Mxp_1
Mxp_2
Pe_1
Pe_2
163
0.5 mm.
1 mm
166
167
162
0.5 mm
172
Pe_2
169
Pe_4
Pe_3
171
Pe_1
168
0.5 mm.
170
NESIPPUS AUSTRALIS NOV. SP

Figs. 162-172



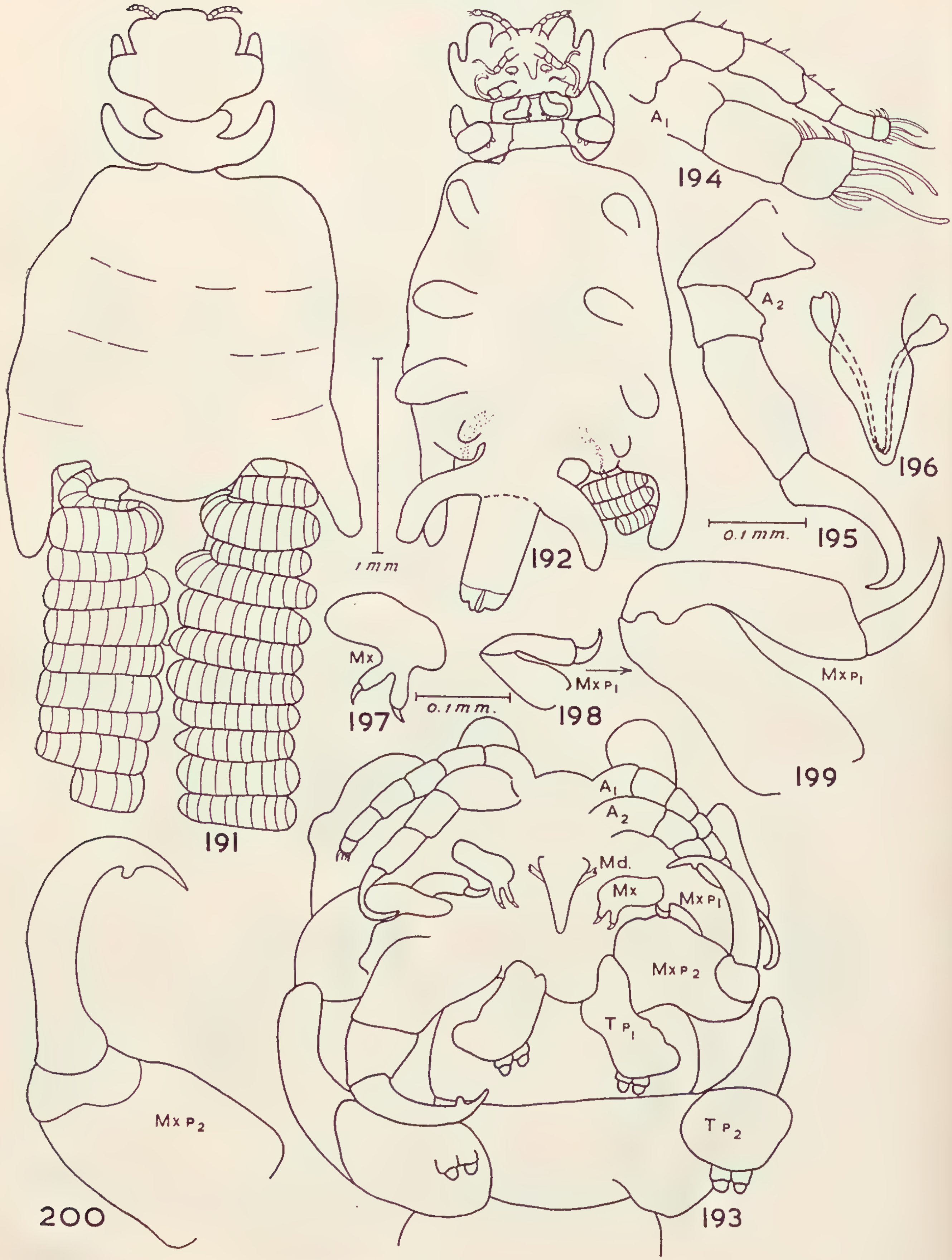
Figs. 173A-181

PARACYCNUS LOBOSUS NOV. GEN. NOV SP.



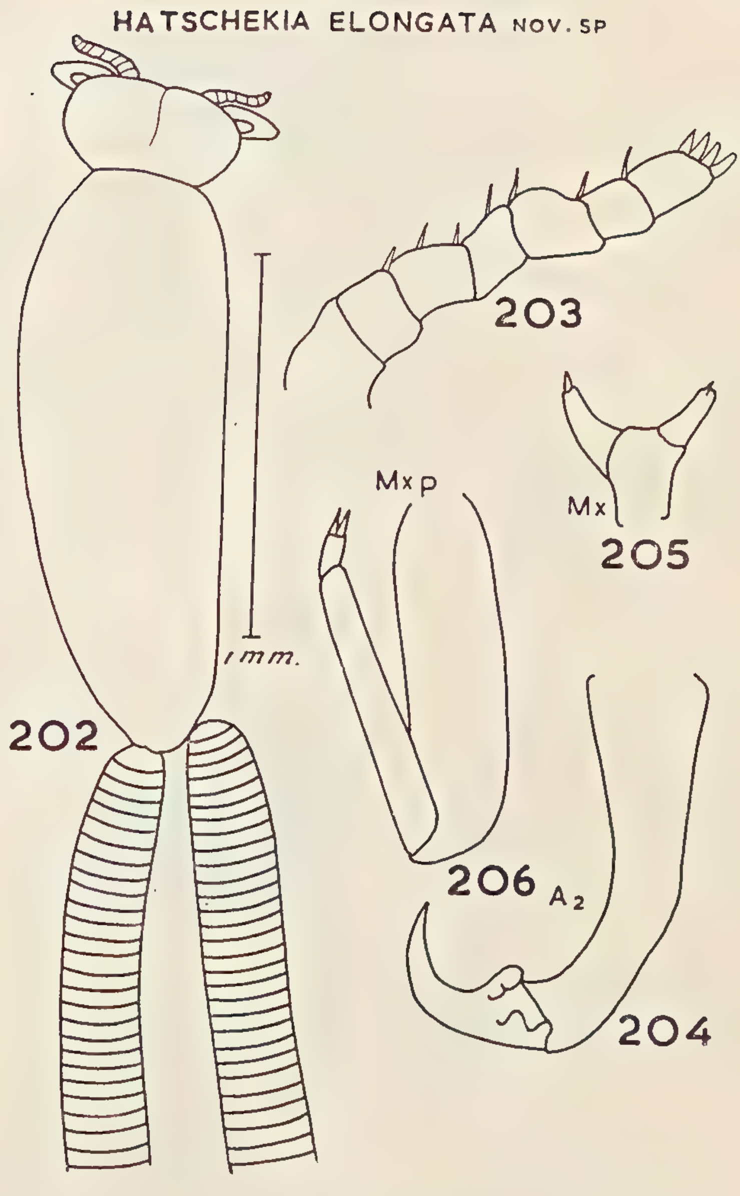
Figs. 182-190

HYPONEO AUSTRALIS NOV. FAM. GEN. ET SP.



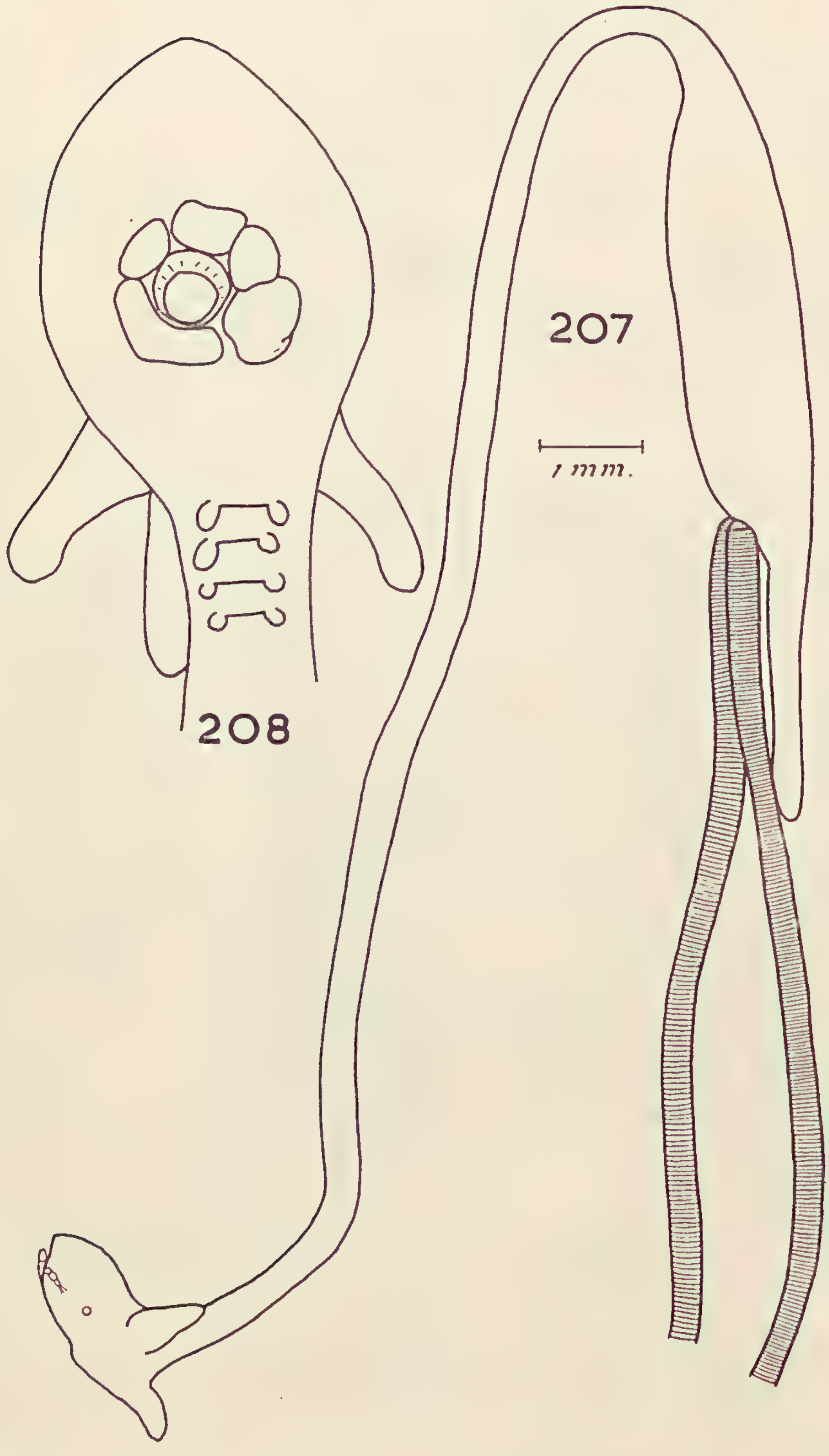
Figs. 191-200

Fig. 201



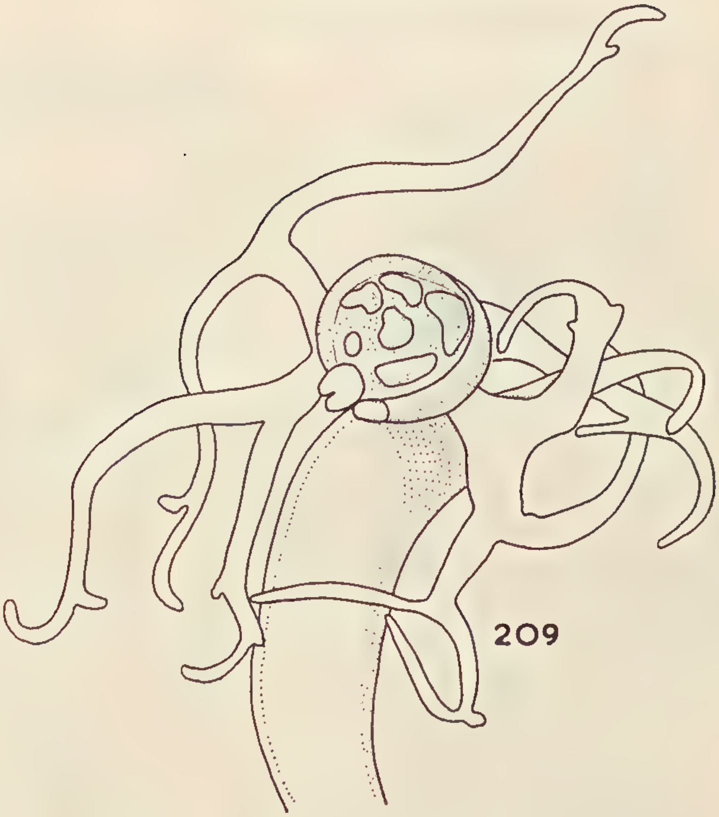
Figs. 202-206

LERNAEENICUS HEMIRAMPHI KIRTISINGHE



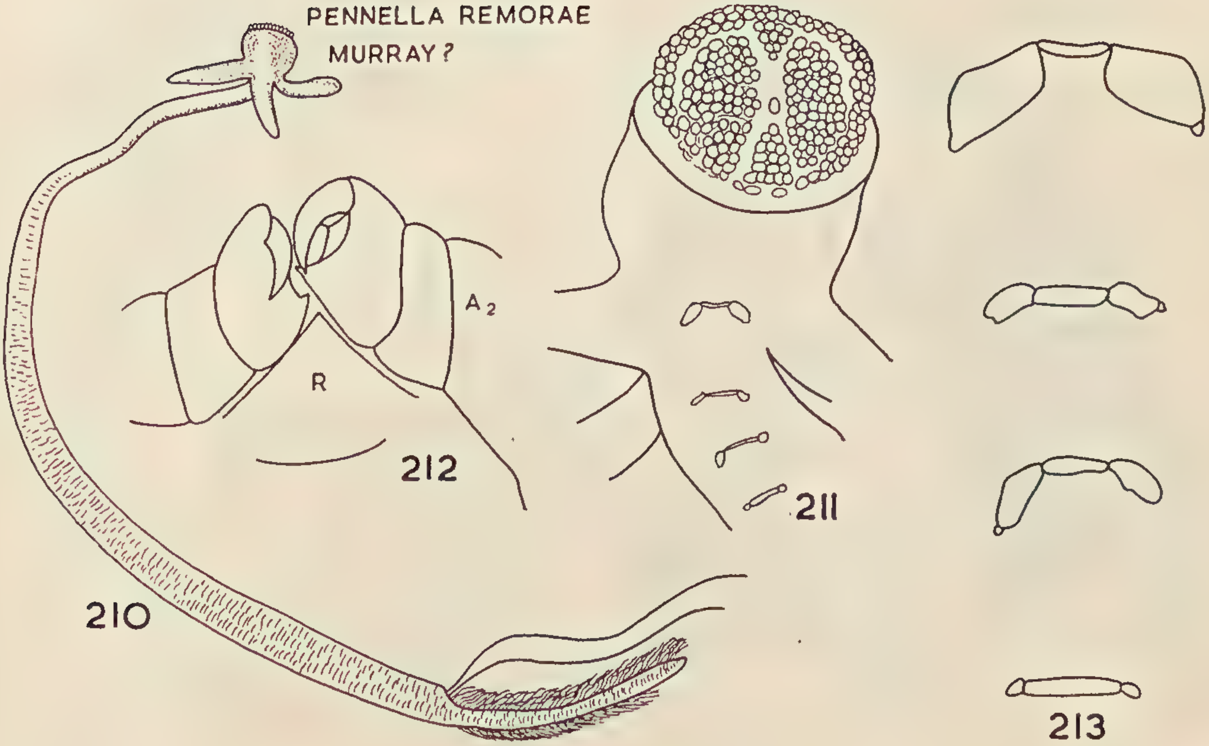
Figs. 207, 208

LERNAEOLOPHUS SULTANUS NORDMANN



209

PENNELLA REMORAE MURRAY?



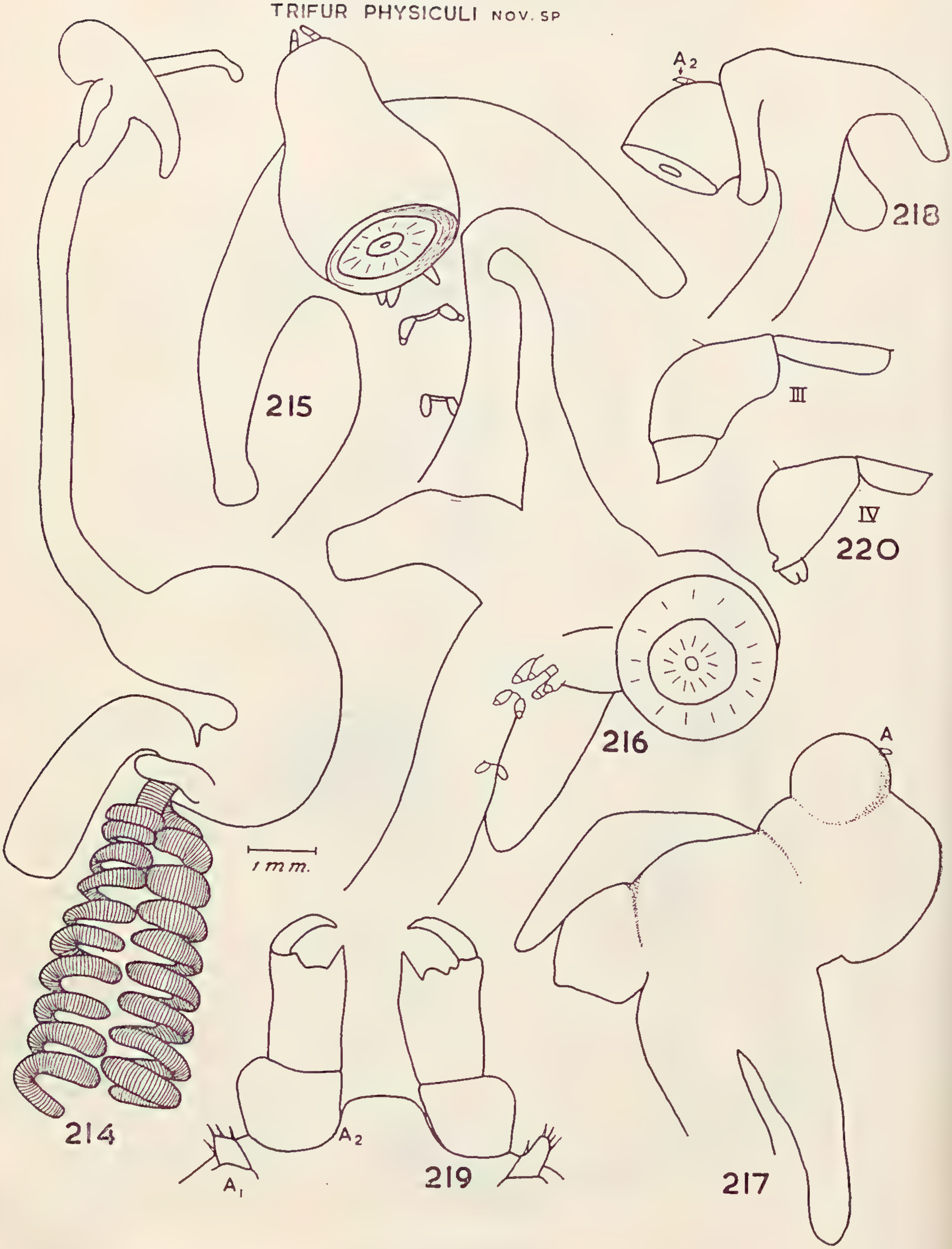
212

211

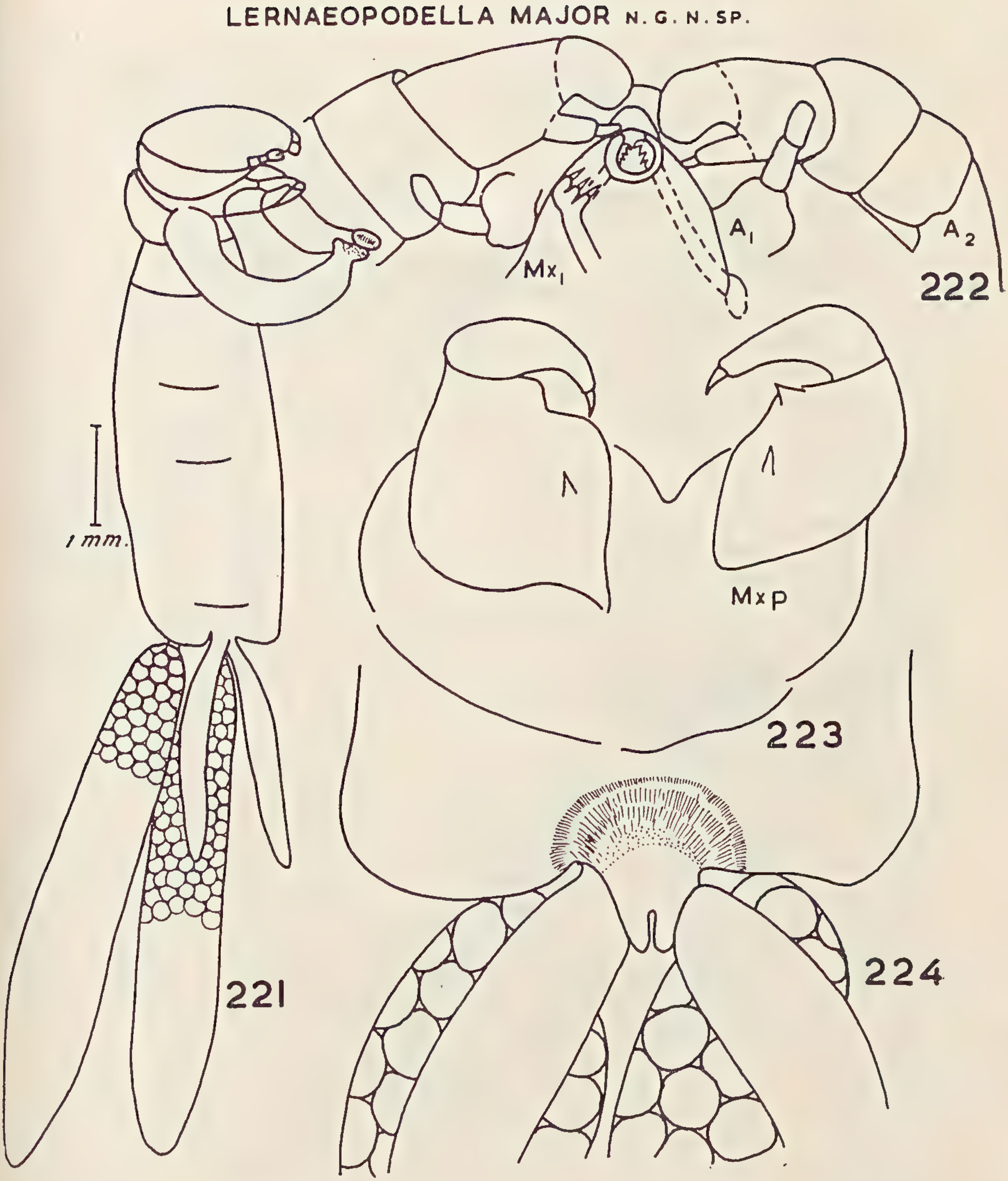
210

213

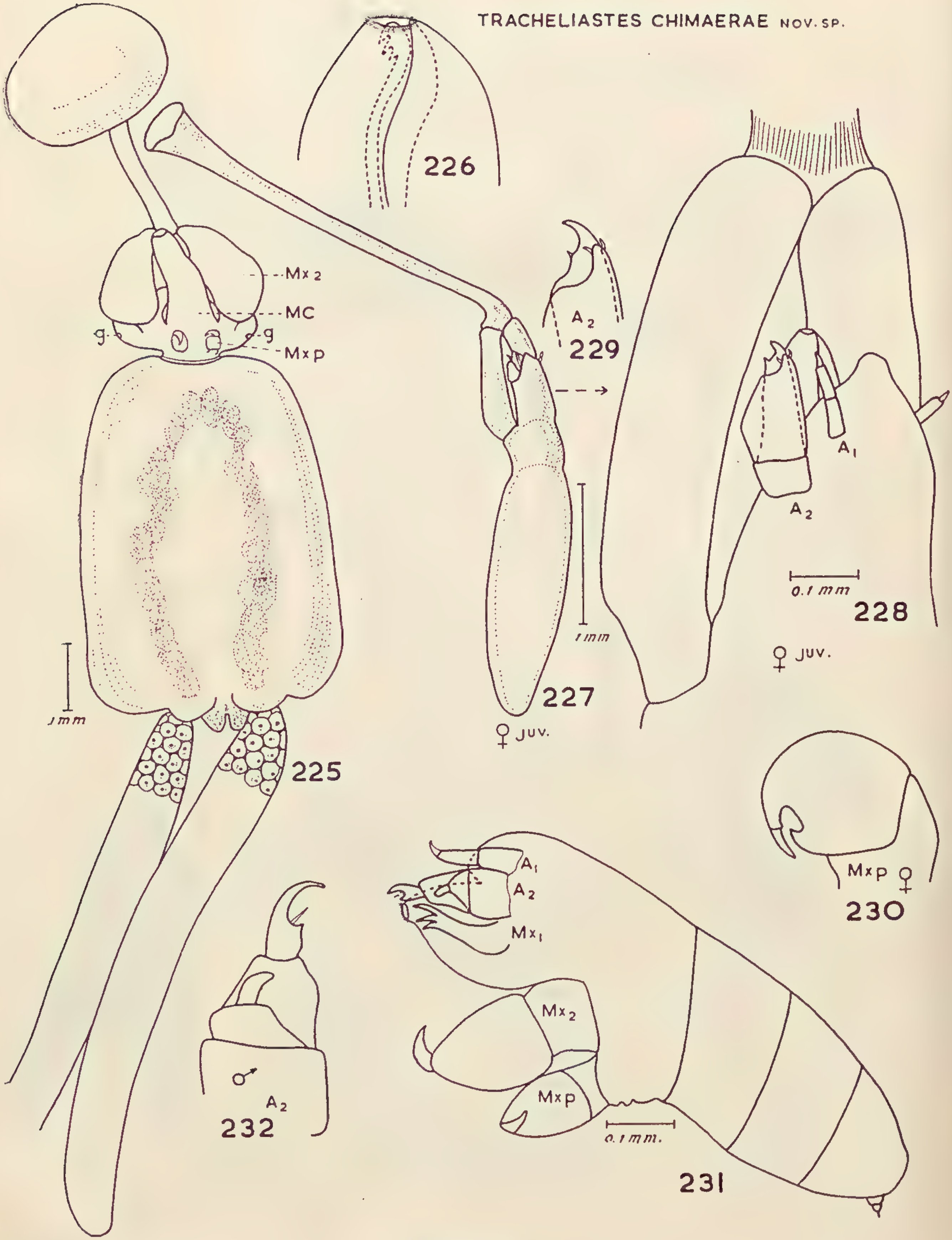
Figs. 209-213


TRIFUR PHYSICULI NOV. SP
215
A2
218
III
IV
220
216
A
1 mm.
214
A2
A1
219
217

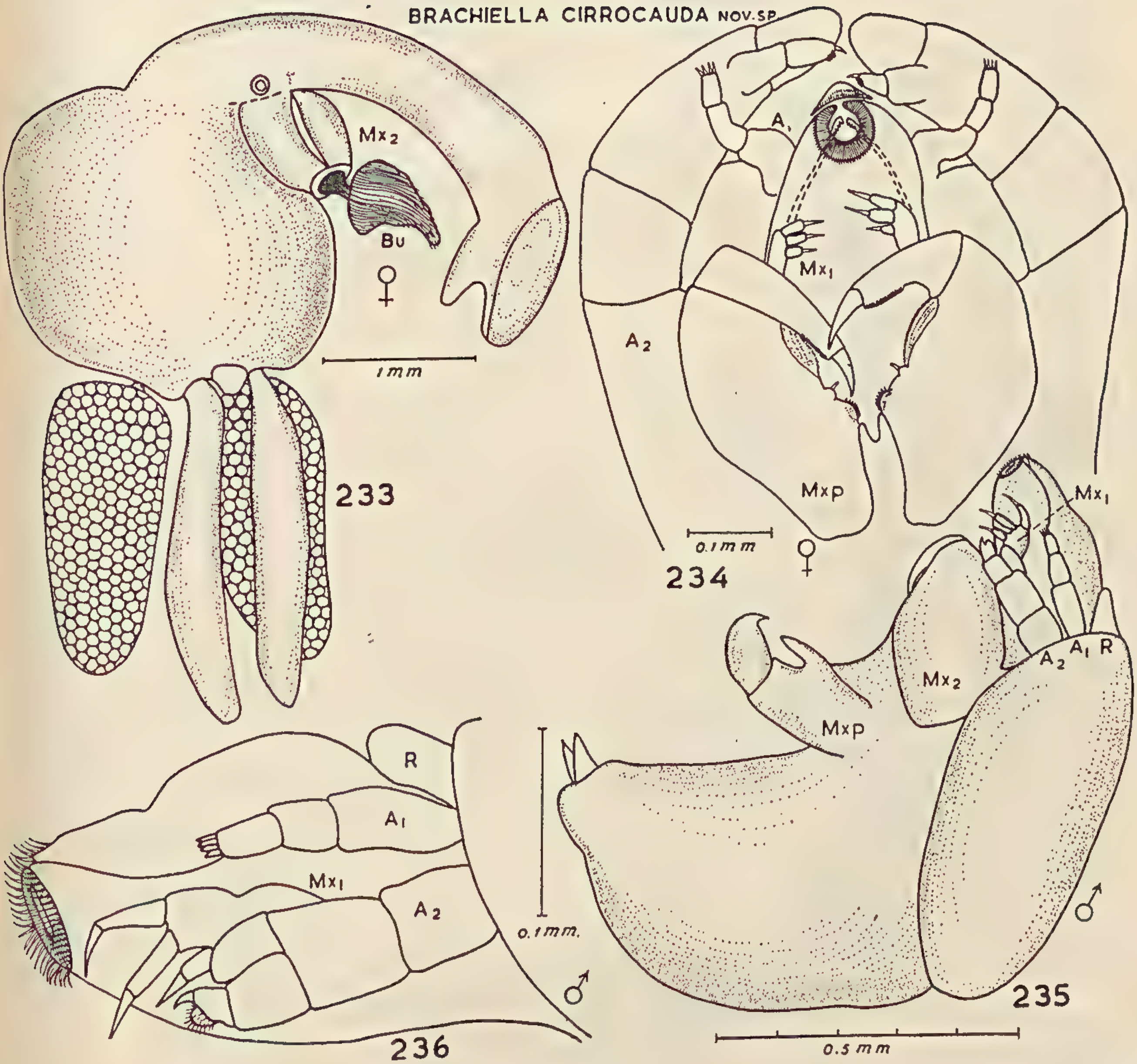
Figs. 214-220



Figs. 221-224

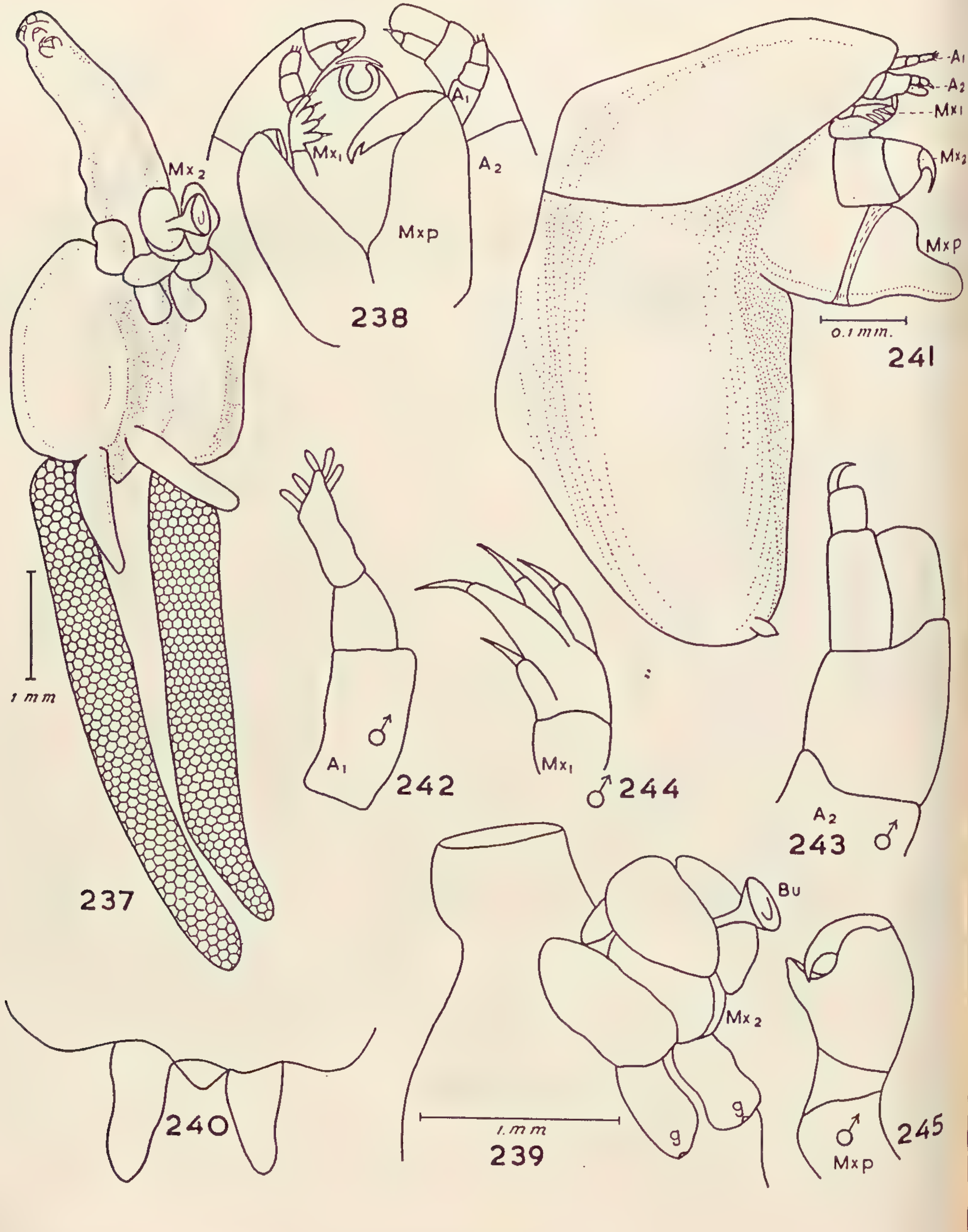

TRACHELIASTES CHIMAERAE NOV. SP.
226
Mx 2
MC
g
g
Mxp
A2
229
1 mm
1 mm
227
♀ JUV.
225
A1
A2
0.1 mm
228
♀ JUV.
Mxp ♀
230
A1
A2
Mx1
Mx2
Mxp
0.1 mm.
231
♂
A2
232

Figs. 225-232


BRACHIELLA CIRROCAUDA NOV. SP.
Mx2
Bu
♀
1mm
233
A1
Mx1
A2
Mxp
0.1mm
♀
234
Mx1
A2 A1 R
Mx2
Mxp
♂
235
0.5mm
R
A1
Mx1
A2
0.1mm.
♂
236

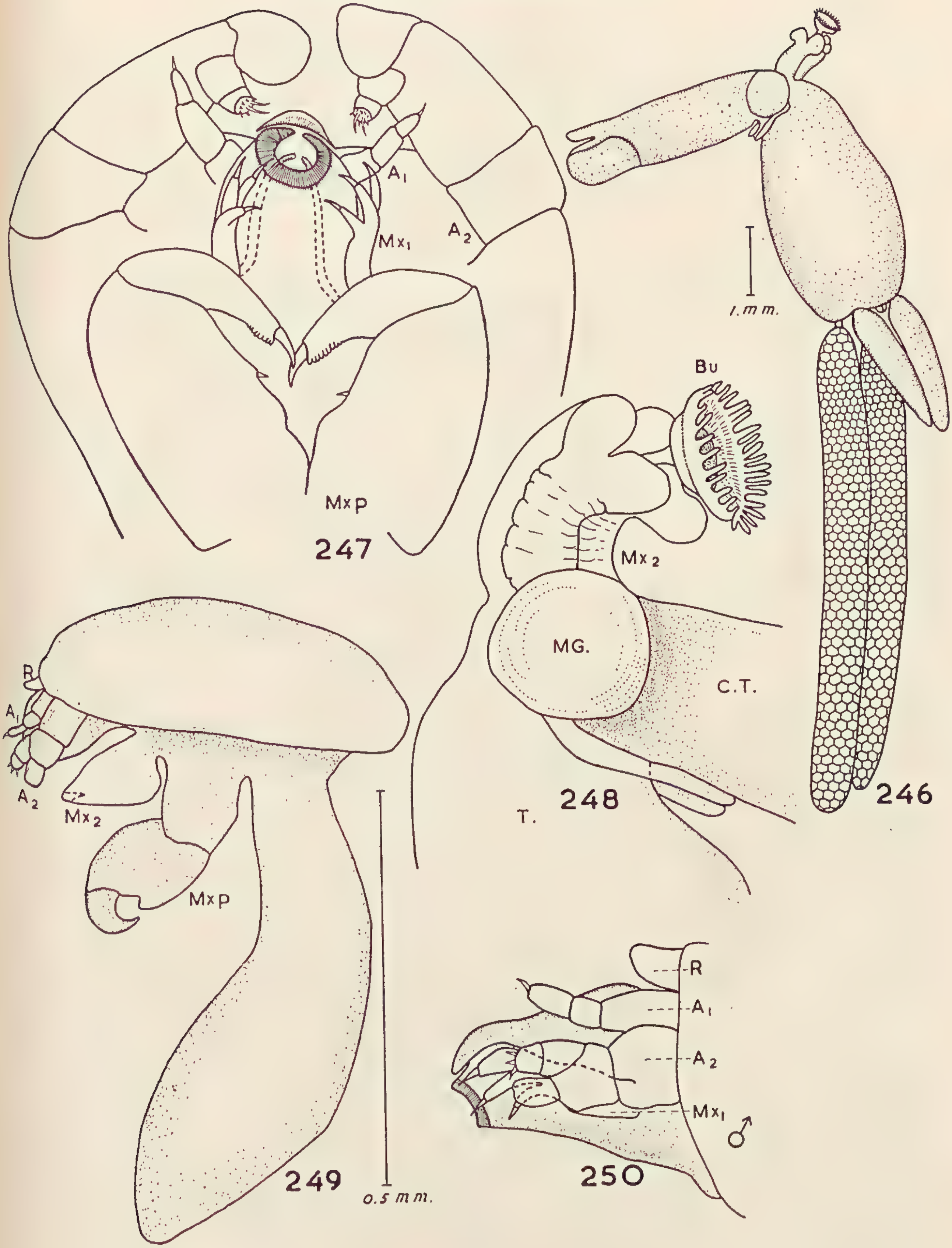
Figs. 233–236

BRACHIELLA CIRRATA NOV. SP.



Figs. 237-245

BRACHIELLA STELLIFERA NOV. SP.



Figs. 246-250

THE HISTORY AND SIGNIFICANCE OF THE FOSSIL *CASUARIUS LYDEKKERI*

By ALDEN H. MILLER

Museum of Paleontology, University of California, Berkeley

(Fig. 1) Manuscript Received 14.5.61

In 1891 Lydekker (pp. 353-354) made known the existence of a fossil cassowary of the Pleistocene of New South Wales, Australia. His report was based on a cast presented to the British Museum by the Trustees of the Australian Museum, Sydney, New South Wales. The original specimen, which according to him was preserved in the " Museum at Sydney " we now know later appeared, unnumbered, among material in the Mining Museum at Sydney. About 20 years ago it was transferred to the Australian Museum and given the number MF 1268.

The significance and identity of the specimen had been lost sight of over the years, and, in 1954, it was placed in the hands of Mr. Leslie F. Marcus, a representative of the Museum of Paleontology of the University of California, U.S.A., with the suggestion that it be studied. In 1960 I began checking the characteristics of this fossil, which consists of the distal end of the tibiotarsus. It seemed clearly to show the configuration of a cassowary rather than that of an emu, which latter has a less tapered proximal extension of the lateral condylar mass on the anterior surface. The question then arose of the distinctness of the specimen from the cassowary reported by Lydekker, the only fossil cassowary on record (Lambrecht, 1933:111). In November of 1960 an opportunity was presented of taking this " unknown " fossil to London, where it was compared with the cast, A 158, now with the additional number B 10394. To my considerable surprise it proved to be the original of the cast. All minor imperfections of the original and details of blood-vessel channels corresponded perfectly; a section of the shaft, about 3 centimetres long on the anterior aspect, had apparently broken out and been lost since the time the cast was made.

In 1911 Rothschild (p. 151), in recording all known ratite birds, fossil and Recent, listed " *Casuarius lydekkeri* Rothsch." from the Queensland Pleistocene. In his key on page 162 he characterizes *C. lydekkeri* as having the " extensor groove [of the distal part of the tibiotarsus] enormously deep " in contradistinction to that of *Casuarius bennetti*. Earlier in the key he had separated the cassowaries with broad tibiae, such as *Casuarius casuarius*, from the more slender types of the *bennetti* group. All the characters used in the key are adapted quite obviously from Lydekker's description of specimen No. 158 and his comparison of it with *Casuarius picticollis* (= *C. bennetti* of current taxonomy). Whether or not Rothschild personally examined No. 158 we do not know, but inasmuch as he used Lydekker's characterizations in contrasting the tibiae, named the form thus diagnosed for Lydekker, and made extensive use of various other ratite material at the British Museum, it is clear that he was basing his name on No. 158 and intended to describe it as a new species. His new name evidently dates from this publication, as I can find no other reference to it earlier in his works. For nomenclatural purposes this publication affords sufficient description to make the name identifiable and available in accord with the rules of that period. No. MF 1268 should be regarded as the holotype in that it was the only specimen known at the time of the original description and No. 158, the cast, was an obvious replica of it.

The source of the specimen has caused concern on two scores. Rothschild's mention of " Queensland Pleistocene " is unexplained and must be presumed to be a lapsus. The Australian Museum has been carrying MF 1268 on its records in recent years as from the diatomaceous deposits at Cooma because a loose label bearing that locality was in an open tray in which the specimen, then unnumbered, was received from the Mining Museum. Other fossils received at the same time in the trays from that museum were chiefly from Bingara and the Wellington Caves. A search for diatoms in the matrix of the shaft of the type showed none. There is therefore no firm basis for the purported derivation from Cooma, and the absence of diatoms throws real doubt on such a source. The locality given by Lydekker, that is, " cavern-deposits of the Wellington Valley ", may therefore be regarded as the correct one although there is no later direct evidence to support the conclusion. This is the view of H. O. Fletcher, of the Australian Museum, who has kindly supplied me with the foregoing data concerning the circumstances of receipt and cataloguing of the specimen at his institution. The British Museum's record of information on the cast repeats the statement of source as the Pleistocene cave deposits of the Wellington Valley.

The type has been compared anew with modern skeletons of cassowaries and emus, including several of the skeletons in the British Museum available to Lydekker in 1891. I can agree with Lydekker's characterizations on all points except for the claimed lack in the fossil of a semilunar pit on the lateral surface of the ectepicondyle. This pit is not well replicated in the cast which Lydekker was using, but it is indeed present in the type. The extensor tendinal groove of the anterior surface of the fossil is deep as he stressed. He did not claim it was actually deeper than in *Casuarius bennetti*, although Rothschild did. My own evaluation of the osteologic characters are that the semilunar pit is not a valid point of difference. Among the three modern skeletons of *bennetti* compared at the British Museum, one has a shallower pit and one a deeper pit than in the fossil and the other is essentially identical. The tendinal groove of the fossil is deeper, with sharper interior border, and the groove is broader than in the Recent examples and the curvature of the outer border is more sigmoid (see fig. 1).

Fig. 1: Type of *Casuarius lydekkeri* Rothschild. Anterior view of distal end of right tibiotarsus, X 1/2.—Drawing by Owen Poe.

The dimensions in millimetres of the fossil and three representatives of *Casuarius bennetti* of the British Museum are as follows:—

	C. lydekkeri	*C. bennetti*		
	Type	No. 1877.1.27.2	No. 1909.12.11.1	No. 1864.7.2.2
Anteroposterior diameter of lateral condyle	34·0	35·8	34·7	35·3
Minimum mediolateral diameter of shaft	20·2	24·9	21·8	24·6
Minimum anteroposterior diameter of shaft	16·5	17·5	15·1	15·5

As may be seen, the size of the Recent and Pleistocene material is similar as Lydekker indicated. Possibly the shaft width is significantly smaller, but it is doubted that this would prove to be statistically valid even with a larger sample of modern skeletons for comparison.

The only characters that would support species separation are the depth and, especially, the shape of the tendinal groove. No other cassowary skeletons examined (*C. bennetti*, 3; *C. casuarius*, 3; and *C. unappendiculatus*, 1) have precisely the same configuration of this area as *lydekkeri*. Still the distinction is slight and I would have no great confidence that further specimens of the modern species would not bridge this small difference. Since Rothschild gave the fossil a species name, it may be retained as a useful designation, but it should be construed as indicating at best a weakly differentiated species.

The significance of the fossil lies in other directions, namely, the paleogeography of the modern small cassowary species which, in the broad sense, it represents. The modern forms of cassowaries are now grouped in three species (see Mayr, 1941:1-3), two of which are large with broad, massive tibiae and rather poorly defined, relatively shallow tendinal grooves on this bone. The third is the small, slender-legged *Casuarius bennetti* with which the fossil has very close affinity, as Lydekker originally made clear. The large *Casuarius unappendiculatus* is confined to New Guinea. *Casuarius casuarius* occurs on New Guinea and the nearby islands of Aru and Ceram and is the only representative of the group today on the continent of Australia, where there is a race in northern Queensland. *Casuarius bennetti* occurs in New Guinea, including Japen Island, and New Britain.

Thus the fossil *Casuarius lydekkeri* shows that the distinctive small *bennetti* group of cassowaries existed in Australia in the Pleistocene and extended far south of the present range of *Casuarius casuarius* to the Wellington Valley of New South Wales.

Acknowledgments

The author is indebted to the Australian Museum and to its Deputy Director, H. O. Fletcher, for the opportunity to study the type of *Casuarius lydekkeri* and for assistance in tracing data. He is grateful to W. E. Swinton and L. N. Port, of the Department of Paleontology, and to J. D. MacDonald, of the Department of Birds, of the British Museum, for the privilege of studying material in the collections of that institution.

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Lydekker, R., 1891 — Catalogue of the Fossil Birds in the British Museum (Natural History), London, 368 pp.

Mayr, E., 1941 — List of New Guinea Birds, American Museum of Natural History, New York, 260 pp., 1 map.

Rothschild, W., 1911 — On the former and present distribution of the so-called Ratitae or ostrich-like birds . . ., *Verh. V. Internat. Ornith. Kongr. Berlin*, 1910, pp. 144-169.

Sydney: V. C. N. Blight, Government Printer—1962

TWO NEW SCLERACTINIAN CORALS FROM AUSTRALIA

By

John W. Wells

Cornell University, U.S.A.

Plates XVI-XVIII Manuscript received 23.5.61

Several years ago two new species of the reef-building coral genus *Coscinaraea* were discovered nearly simultaneously in the extreme eastern and south-western parts of Australia. The writer is indebted to Mrs. Lois Marsh and Mr. E. P. Hodgkin, of the University of Western Australia, and Mr. R. W. George, of the Western Australian Museum, for a suite of specimens of *C. marshae*, and to Mr. K. E. W. Salter, of the University of Sydney, and Mr. F. A. McNeill, of the Australian Museum, for specimens, photographs, and other data on *C. mcneilli*, and to Dr. D. F. Squires, of the American Museum of Natural History, and Mr. E. de Villa, of Sydney, for photographs of the type of the latter species.

The two new species described below occur at the extreme southern limits of hermatypic corals in eastern and south-western Australia. The most southerly occurrence of *Coscinaraea* known to this time is at Rundle Island (23° 30° S.) on the Great Barrier Reefs (Wells, 155, p. 25, and chart), about 600 miles north of Sydney and where the winter minimum temperatures are about 17° C. The genus has not been previously reported from north-western or western Australia.

In eastern Australia the writer (1955) has noted the occurrence of a few reef coral genera as far south as Sydney: *Montipora*, *Cyphastrea*, *Turbinaria*, *Stylocoeniella* and *Plesiastrea*. To this short list is now added *Coscinaraea mcneilli* n.sp., from Manly Cove and vicinity, in waters where the temperature range is from 12° C. in June to 24·5° C. in January.

From Western Australia comes *Coscinaraea marshae* n. sp., represented by a number of specimens from Rottnest Island off Fremantle (32° S.) southward to Cape Naturaliste and Geographe Bay (33° 30′ S.). The winter minimum temperatures here are considerably higher and within the normal tropical range (about 18° C., according to E. P. Hodgkin) and the coral fauna is richer than that of approximately the same latitude at Sydney (34° S.). The following species, in addition to *C. marshae*, are found: *Favites abdita* (Ellis and Solander), *F. magnistellata* (Milne-Edwards and Haime), *Platygyra sp. cf. P. lamellina* (Ehrenberg), *Montipora sp. cf. M. multiformis* Bernard, *Turbinaria sp. cf. T. danae* Bernard, *Pocillopora damicornis* (Linnaeus), *Oulophyllia crispa* (Lamarck), *Goniastrea benhami* Vaughan, *Plesiastrea urvillei* Milne-Edwards and Haime, *Tubastrea aurea* (Quoy and Gaimard), *T. diaphana* (Dana), and *Homophyllia australis* Milne-Edwards and Haime. Notable is the absence here, as well as in the vicinity of Sydney, of species of the protean but more tropical genera *Acropora* and *Porites*. *Plesiastrea urvillei* and *Homophyllia australis* are exceptional in that their northern limit seems to be at or near Houtman's Abrohlos (29° 30′ S.) in the west, but they extend down and around the southern coast of Australia (type locality of *H. australis* is Port Lincoln, South Australia), the northern coast of Tasmania, and north probably as far as Moreton Bay, Queensland (27° 30′ S.). There is a specimen of *H. australis* in the Australian Museum (No. 12630) labelled as coming from Lord Howe Island. This record needs verification.

Family **SIDERASTREIDAE**

Genus **Coscinaraea** Milne-Edwards and Haime, 1848

Crossland (1941) discussed the type species, *C. monile* (Forskål), and its synonyms, and figured Forskål's type specimen. The writer briefly considered most of the Recent species in 1954 (p. 446). *C. monile* and *C. labyrinthica* (Audouin) are confined to the Red Sea and Indian Ocean; *C. ostreaeformis* van der Horst (Wells, 1954, p. 446, pl. 155, f. 5, 6, and Matthai, 1948, pl. 8, figs. 30-36 (as *C. monile*)) is a deep-water form in the Indo-Pacific; and *C. columna* (Dana) and *C. fossata* (Dana) have been found only in the Pacific.

Coscinaraea mcneilli n. sp.

Plate xvi, figs. 1-3

Corallum a broad expanded thamnasterioid plate attached basally or laterally to the substratum in the mode of a bracket fungus, up to 10 mm. thick. Lower surface non-epithecate, common wall solid and imperforate, covered with relatively broad, rounded, granulated, equal costae with narrow interspaces; the fine costal granules or spinules are scattered over the costae rather than forming regular rows. Dimensions of holotype (a piece from a large colony): 9 x 16 cm. Colony-formation by circumoral budding, new centres grouped in roughly

concentric rows separated by very low collines. Over parts of the calicular surface collines appear to be absent. Calices shallow, 2-3 mm. in diameter, their centres 3-4 mm. apart. Septa numbering 15-20, of which 12-15 extend to the columella, equal and thick midway between centres, thinning evenly towards the columella, imperforate, strongly spinulosely beaded laterally and marginally. Over the low walls and collines the septa number 20-26 per centimeter. Columella small, trabecular, papillate at surface, not as sharply differentiated from inner coarse beads of septa as it is in most species of the genus. Corallite walls, except the basal wall, scarcely differentiated and represented by two or three vague vertical rows of synapticulae.

This species groups with *C. monile*, *C. columna* and *C. ostreaeformis*—species in which collines are weakly developed. It differs clearly from the first of these in the smaller calices (7-9 mm. in *C. monile*) and growth-form, from *C. columna* by its larger calices in which nearly twice as many septa reach the columella, and from *C. ostreaeformis* by its deeper calices (calices may be protuberant in *C. ostraeaformis*) and proportionally finer septa. The bracket growth form is much like that of the quiet-water form of *C. columna* described by the writer from the Marshall Islands (1954, pl. 179, f. 2). This growth-form is well shown in an underwater photograph (Pl. XVI, f. 3), taken by E. de Villa, of the entire colony some 60 centimetres long from which the holotype piece was broken.

Material.—Holotype: Australian Museum No. G13638 (this is the specimen figured by Gillett and McNeill, 1959, p. 51, f. 41); paratype: A.M. No. G13639 (small piece of this in the U. S. National Museum).

Occurrence: Sydney Harbour (Port Jackson), New South Wales. Holotype from Fairlight, a small bay near Manly, depth 25 feet, collected by E. de Villa, aqua-lung diver. Paratype from about same depth nearby off North Headland, collected by W. Gibson, aqua-lung diver.

Coscinaraea marshae n. sp.

Plate xvii, figs. 1-4; plate xviii, figs. 1-3

Corallum open caliciform, attached centrally by a stout stalk. Old colonies expanded laminar, very thick centrally, with nearly even calicular surface. Common wall of lower surface solid, imperforate, about 2 mm. thick peripherally, non-epithecate, with sharp, equal, faintly beaded costae corresponding to all the marginal septa. Colony-formation by circumoral budding, resulting in short, irregular series in earlier stages, tending to become long, nearly continuous and concentric with the margin. Series 7-10 mm. wide, separated by high, rounded collines over which the septa dip steeply to the valley floors. Depth of valleys about 4 mm. Marginally the collines are asymmetric in profile, steeper on the outer side, giving the valleys an outward-looking aspect. One or two centimetres in from the margin, however, they are nearly symmetrical. Over the collines the septa are equal, numbering 25-30 per centimetre. Calicular centres are 6-8 mm. apart, with lamellar or trabecular linkage. Septa of higher cycles unite irregularly with those of lower cycles so that about half (15-18) extend to and join the columella. Columella small, trabecular, with a few surface papillae, sunk in a shallow pit below the inner ends of the major septa. Corallite walls represented only by a few synapticulae (pl. XVIII, fig. 3). Dissepiments thin, convex. Compared with other species of the genus the septa are thin, and imperforate as in *C. mcneilli*. Living polyps yellow-brown to brown.

At first glance the habit and aspect of this handsome species suggest *Leptoseris*, but the septal structures are those of *Coscinaraea* and other siderastreids. The serial nature of the calices groups it with the other more or less meandrine species, *C. fossata* and *C. labyrinthica*. In neither of these, however, do the series show anything approaching the more or less regularly concentric arrangement of *C. marshae*, in which the valleys are proportionally wider and more open; the septa, also, are much thinner and less perforate than in most other species, and generally narrower than the interspaces rather than two or three times as wide. This is the only species with a distinctly and consistently caliciform growth form.

Although the caliciform corallum and mode of colony-formation are constant in the specimens examined, there is a wide variation in the development of the collines and the spacing of the calicular centres. The holotype—diameter 17 cm., height 10 cm., concavity 3·5 mm. (pl. XVII, figs. 1, 2)—is at one end of the range, with highly developed, roughly concentric, high, narrow collines and centres 5 mm. apart. At the other end is a colony 24 cm. in diameter, 9 cm. high, with a nearly flat (concavity, 1 cm.) calicular surface, very low, relatively broad collines and centres spaced 6-8 mm., resembling *C. mcneilli* but with very thick corallum. A thin corallum 17 cm. in diameter and 6 cm. high (pl. XVIII, fig. 1) also has a nearly flat calicular surface, with low, relatively narrow collines developed on the inner side of the widely-spaced (5-15 mm.) calicular centres, especially near the margin where the aspect is much like that of *Leptoseris* or *Mycedium*. These three specimens would appear to be as many species, but they are interconnected by nine other specimens.

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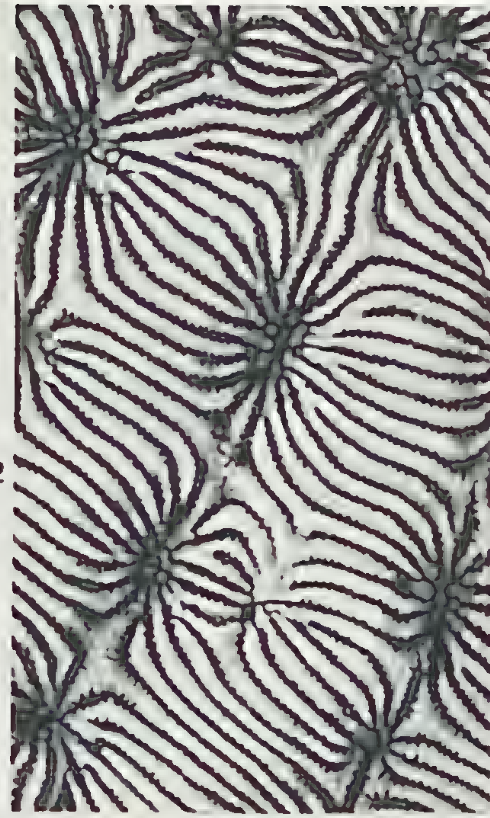

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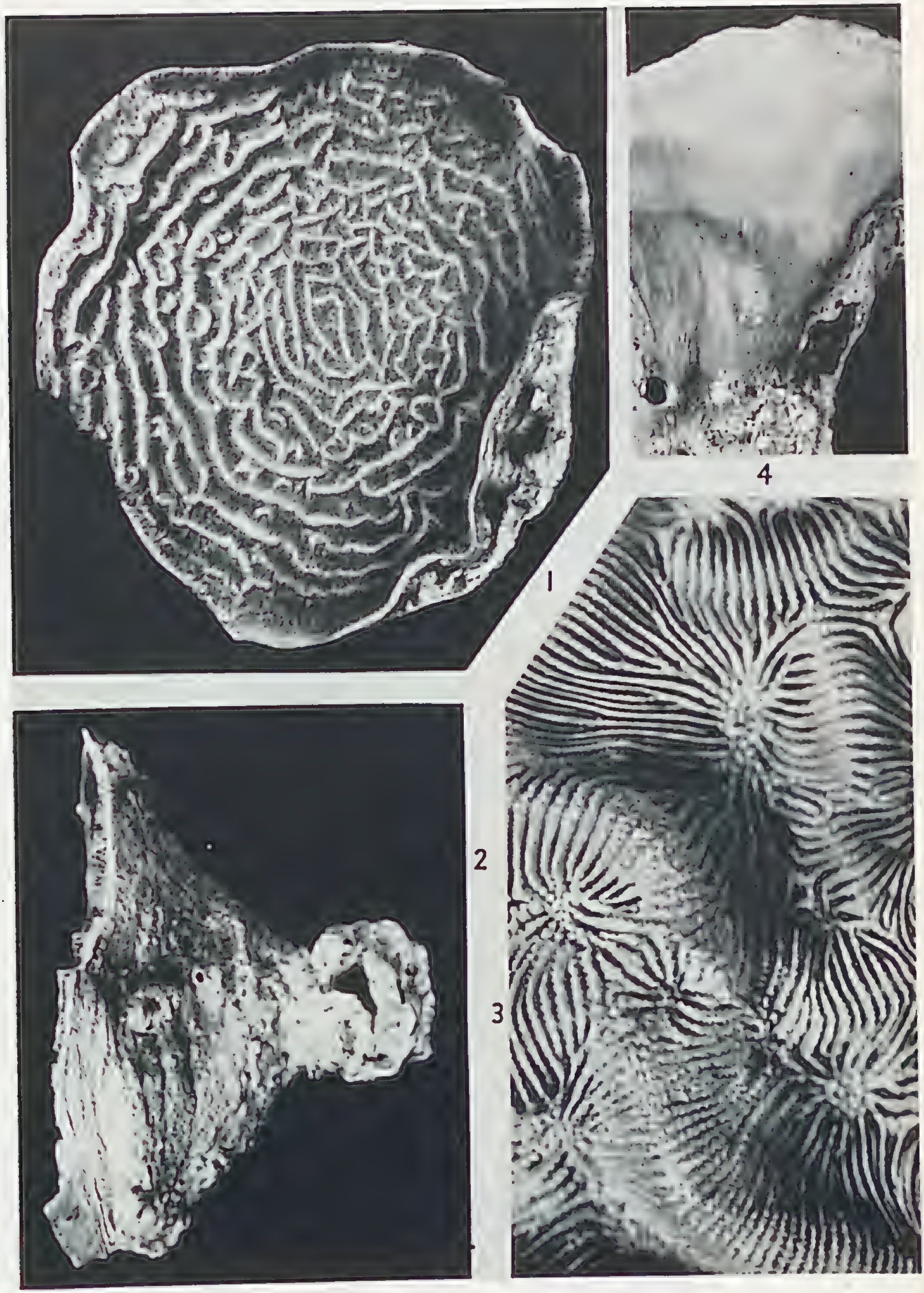
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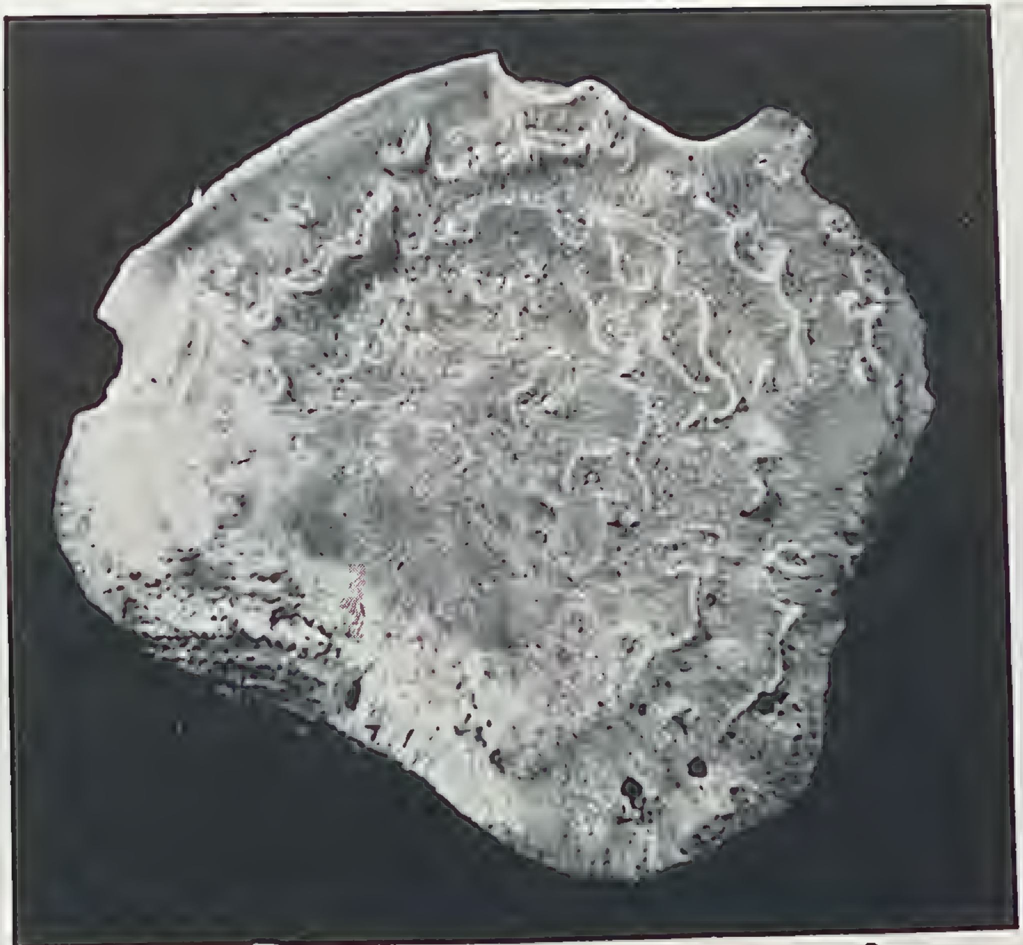

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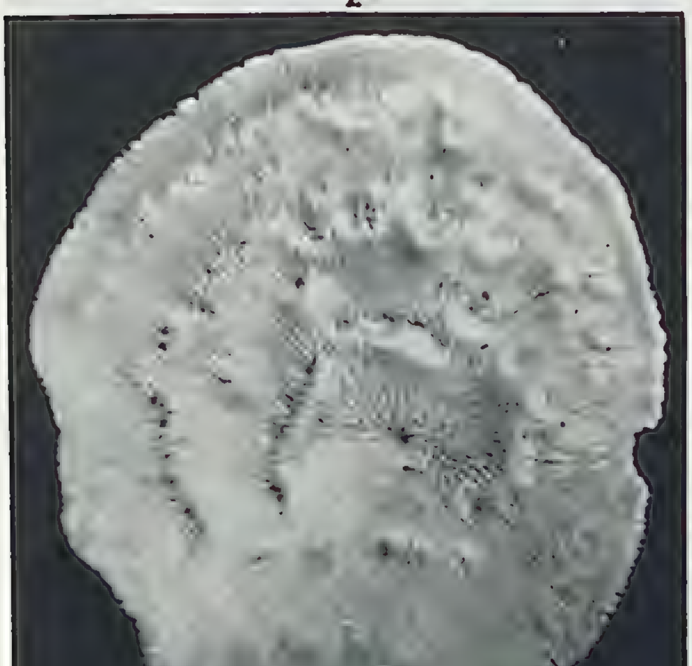

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Material.—Holotype: Western Australian Museum, No. 104-58; paratypes: W.A.M.: Nos. 52-29, 59-59, 100-58, 101-58, 102-58, 103-58; Australian Museum (1); U.S. National Museum (2).

Occurrence: Western Australia at various localities between Fremantle and Geographe Bay; holotype and paratype No. 101-58: Point Clune, Rottnest Island, depth 10 feet; paratypes Nos. 102-58, 103-28: Cathedral Rocks, Rottnest I.; paratype 59-59: 1·5 miles off Dunsborough, Geographe Bay, depth 25 feet (" from a crevice in a rocky ledge "); paratype No. 52-59: Eagle Bay, Cape Naturaliste, depth 30 feet (" in a rock crevice "); paratype No. 100-58: Woodman Point near Fremantle; paratypes (2 specimens, one in Western Australian Museum, one in Australian Museum): Cathedral Rocks, Rottnest I.; paratype (Dept. Zoology, Univ. Western Australia): Cape Vlaming, Rottnest I.; paratypes (2 specimens in U. S. National Museum): Rottnest I.

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Explanation of Plates

PLATE XVI

Coscinaraea mcneilli n. sp.

Figs. 1, 2: *C. mcneilli*, holotype (A.M. G13638), calicular surface, x 1/2; calices, x 6. Photographs by courtesy of D. F. Squires.

Fig. 3: *C. mcneilli*, entire colony from which holotype piece was taken, *in situ*, depth 25 feet, Fairlight, Sydney Harbour. Width, about 60 centimetres. Photograph by E. de Villa.

PLATE XVII

Coscinaraea marshae n. sp.

Figs. 1, 2, 3: *C. marshae*, holotype (W.A.M. 104-58): 1. Calicular surface, x 1/2; 2. lateral aspect, x 1/2; 3. Calices, x 6.

Fig. 4: *C. marshae*, paratype (W.A.M. 101-58): exterior of part of small colony, showing costate common wall, x 1.

PLATE XVIII

Coscinaraea marshae n. sp.

Fig. 1: *C. marshae*, paratype (W.A.M. 103-58): *Leptoseris*-form, calicular surface, x 1/2.

Fig. 2: *C. marshae*, paratype (W.A.M., Cathedral Rocks): young colony, *Leptoseris*-form, x 1/2.

Fig. 3: *C. marshae*, paratype (W.A.M. 59-59): natural vertical section, lateral faces of septa, synapticulae, and endotheca, x 4.

Sydney: V. C. N. Blight, Government Printer—1962

Two Spirorbid Tubeworms (Serpulidae, Polychaeta) from Eastern Australia

By B. Wisely

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(Figs. 1-18)

Manuscript received 20. 2. 62

INTRODUCTION

This paper describes the systematic features of two species of *Spirorbis* the larvae of which have been used in experimental anti-fouling investigations at the C.S.I.R.O. Marine Laboratory. Dew's (1959) revision of the Australian Serpulidae did not include the genus *Spirorbis*, but she noted that it was well represented and listed the references to the five species previously described from the area.

MATERIAL AND METHODS

All material was collected from the *Posidonia* sp. beds which extend from the C.S.I.R.O. Marine Laboratory's jetty across the entrance to Gunnamatta Bay in Port Hacking, Sydney. Since the *Posidonia* sp. was not observed in flower, its specific identity could not be established.

Dissections of the tubeworms were made on fresh material immersed in the polyvinyl lactophenol mountant recommended for polychaete setae preparations by Knox (1951).

SYSTEMATICS

Genus Spirorbis Daudin 1800

Body asymmetrical, less than five thoracic segments; operculum usually with a terminal calcareous plate; tube calcareous, coiled in either a sinistral or dextral spiral; incubation of the eggs either in the tube or the operculum.

Spirorbis convexis, sp. nov.

Tube.—In solitary individuals the tube forms a flat, sinistral spiral (fig. 1), but in crowded populations the tube whorls may twist irregularly or coil on one another to form a tall spiral. The upper surface of the tube is white and shiny, and does not bear longitudinal ridges; its surface is smooth except for slight transverse growth striae. The diameter of 25 specimens each containing well developed larvae averaged 1·35 mm. (range 0·81—1·88 mm.).

Setation.—The setae of the dorsal and ventral bundles of the first thoracic segment are similar. Each of these bundles contains five main setae with well-developed blades, notches and fins (fig. 2.). The blade of each seta has fine serrations and there are 3-4 coarse teeth on the fin. The outline of the seta opposite the notch is unusual in that it is distinctly convex; it is to this feature that the proposed specific name refers. Each bundle has three fine capillary setae. The dorsal and ventral bundles of the second segment each have 7-8 setae bearing simple blades (fig. 3) which vary a little in size and amount of curvature. A few capillary setae are present. The bundles of the third segment are similar to those of the second, but the shape of the setae is slightly different (cf. figs. 3, 4).

Branchiae, operculum and incubation.—The six non-pigmented branchiae each bear 14-20 filaments; the terminal filaments are blunt (fig. 5). The operculum, which is transparent, arises from the right side of the animal and consists of a smooth, approximately cylindrical pedicel terminating in a flattish, rounded plate. The distal face of the plate may be convex, concave or

flat (figs. 6, 7), and it has a central calcified area. The eggs, which are reddish-brown and retain this colour throughout development, are incubated within the tube. When there are less than eight eggs, they are arranged linearly, but when larger numbers are present the eggs are arranged in a double row along most of the length of the egg mass (fig. 8).

Breeding season.—During 1960 and 1961 very large numbers of larvae were obtained from adults collected during October, November and December in Gunnamatta Bay.

Larvae.—The average number of larvae present in the 25 specimens referred to earlier was 15 and the range 4-28. There are four features of possible systematic value: (1) a reddish-brown coloration, deeper in the central areas of the thoracic and abdominal segments, and across the prototroch (fig. 9); (2) a lack of frontal eyespots; (3) a characteristic angle of 30-45° between the caudal setae; (4) an apparent lack of " attachment " or " shell " glands. Hoglund (1951) noted that in *S. spirillum* (Fabricus, 1780) " shell " glands were also absent. The length of *S. convexis* larvae varies between 310 and 330 μ. When they are fully developed they swim out of the adult tube at intervals of 10-15 seconds and are photopositive; their larval reactions have not been investigated in detail, but exploratory behaviour reminiscent of that recorded for *S. borealis* Daudin (Wisely, 1960) has been observed on several occasions.

Metamorphosis.—The appearance of a young adult 24 hours after attachment at *c.* 20°C. is shown in figure 10. At this stage rudimentary branchiae and an operculum have differentiated; despite the apparent absence of " attachment " or " shell " glands, the animal is firmly attached to the substratum. In contrast to the other species described here (*S. lamellosa* Lamarck 1818) the proximal part of the transparent primary attachment tube is straight, cylindrical and smooth-walled; the more distal curved part has a corrugated outline.

Types.—Holotype W.3749 and paratypes W.3750 in the Australian Museum, Sydney. Paratypes in the British Museum (Nat. Hist.).

Type locality.—Gunnamatta Bay in Port Hacking, Sydney, N.S.W. 34°04·5′S., 151°09′E. Abundant on *Posidonia* sp. leaves.

Discussion.—The tube of *S. convexis* differs markedly from those of the other three sinistral species described previously from the Australian area. It does not possess the median rib described by Lamark (1818) and figured by Chenu (1843, plate 1, fig. 3) for *S. incisus* Mörch 1863; nor the three rounded ribs described by Lamarck (1818) and figured by Chenu (1843, plate 1, fig. 4*a*). The terminal portion of the tube does not turn downwards, like a spout, as it does in *S. inversus* Bush 1904.

Spirorbis lamellosa Lamarck 1818

Tube.—The tube (fig. 11) forms a dextral spiral with the aperture in mature specimens often slightly elevated and funnel-shaped. There are usually three rounded ridges running longitudinally along the upper surface of the tube, and sometimes a faint fourth ridge is discernible on the convex side of the tube. The upper surface of the tube is dull, bears prominent curved growth striae, and is yellowish-brown with small white, brown and purple markings. The prominence of the ridges and the colour of the tube are variable, but the curved growth striae are consistently prominent. The aperture has two main indentations in its margin adjacent to the central ridge. The diameter of 25 specimens each containing well-developed larvae averaged 1·65 mm. (range 1·31-1·88 mm.).

Setation.—The dorsal and ventral bundles of each thoracic segment vary more than in the previous species. The dorsal bundle of the first thoracic segment consists of five long setae with coarsely serrated blades, evenly rounded at their bases, and lacking fin-like expansions or notches (fig. 12). The blade size increases progressively from the most anterior to the most posterior in the series. A few fine tapering capillary setae are present. The seven setae of the second thoracic dorsal bundle are not serrated, but are slightly flattened and expanded into simple blades near their distal ends (fig. 13). The third thoracic dorsal bundle is similar. The ventral bundles are smaller and closer together. The four setae of the first bundle are shorter than the remainder and possess simple blades similar to those of the second dorsal bundle. One of the setae is curved. The second bundle is similar but two of the setae are curved. All seven setae of the third bundle are curved.

Branchiae, operculum and incubation.—Each of the seven branchiae bears 16-20 filaments. The terminal filament is attenuated into a fine process. In large specimens this attenuation is longer than any of the other filaments. Red markings are sometimes present on the branchial bases. The developing operculum (fig. 14) is transparent and consists of a short pedicel, chamber and a circular concave plate. Within the chamber, and proximally to the plate, there is an opaque white rod with two lateral arms; from the base of this rod an opaque white ring runs parallel to the periphery of the plate (fig. 15). On the convex side of the chamber there is an opening bordered

distally by a concave border, and laterally by a pair of thin flaps. In mature specimens in which the operculum becomes larger and functions as an incubation chamber (fig. 16), this opening persists as a transverse slit which probably allows sea-water circulation around the developing larvae. When the eggs first appear in this incubation chamber they are green, but later they become brownish. When the larvae are near liberation their conspicuous red eyespots and white thoracic "shell" glands give the operculum a distinctive mottled appearance. During the later stages of incubation the transverse plate which delimites the distal incubation chamber from the proximal cup becomes white. The larvae escape through the slit in the incubation chamber and the latter is then shed and a new incubation chamber differentiated from the basal cup. Occasional specimens are found in which two incubation chambers containing larvae are present; evidently in such cases the second incubation chamber becomes functional before the primary has been shed.

Breeding season.—Similar to *S. convexis.*

Larvae.—The average number of larvae present in the 25 specimens referrred to earlier was 19 and the range 13-31. The larvae are between 340 and 360μ. in length, transparent, and photopositive at liberation. The general anatomical features are shown in fig. 17. Possible systematic features are : (1) two prominent white " shell " glands on the thorax; (2) a dark green coloration centrally in the thoracic and abdominal segments; (3) the almost parallel caudal setae.

Metamorphosis.—When it attaches, the larva adopts a curved position resulting in a markedly curved primary attachment tube (fig. 18). The proximal end of this is frequently ruptured and the walls are smooth. The thoracic " shell " glands do not seem to contribute to the formation of the primary attachment tube. They appear to be unchanged during its formation, but gradually disappear as the secondary calcareous tube is formed. Metamorphosis of this species appeared to be more rapid than that of *S. convexis*; the branchiae, after 24 hours at *c.* 20°C., were further developed (cf. figs. 10, 18).

Specimens examined include W.3751 in the Australian Museum, Sydney, and a batch in the British Museum (Nat. Hist.).

Type locality.—Lamarck (1818) gave this as Australia. The present material was taken from Gunnamatta Bay in Port Hacking, Sydney, where it occurs abundantly on *Posidonia* sp. leaves.

Discussion.—It has been difficult to evaluate the status of this species. According to Bush (1904) *S. tridentatus*, the other dextral species, described from Port Phillip, Australia, differs " from all known forms in having the lower surface of the whorls distinctly smaller than the upper surface, the sides inclined outwards forming a carinated shoulder. " The whorls of the present material are vertical to the substratum. The material seems to fit Lamarck's (1818) description of *S. lamellosa*, i.e. " tube pourvu de trois côtes longitudinales, lamelleuses denticulées striées dans les intervalles, et s'enroulant en un disque subombilique. " Also, fig. 11 of the present paper is almost indentical with Chenu's (1843) plate 1, fig. 4 of the tube of *S. lamellosa* and was prepared before Chenu's figure was seen. Presumably Lamarck, in calling the species *lamellosa*, considered the lamellate appearance of the growth striae to be the most characteristic tube feature. Since this is also true for the present material, it is not proposed at this stage to differentiate the two.

ACKNOWLEDGMENTS

This work forms part of a programme on the biology of fouling organisms carried out in co-operation with the Royal Australian Navy.

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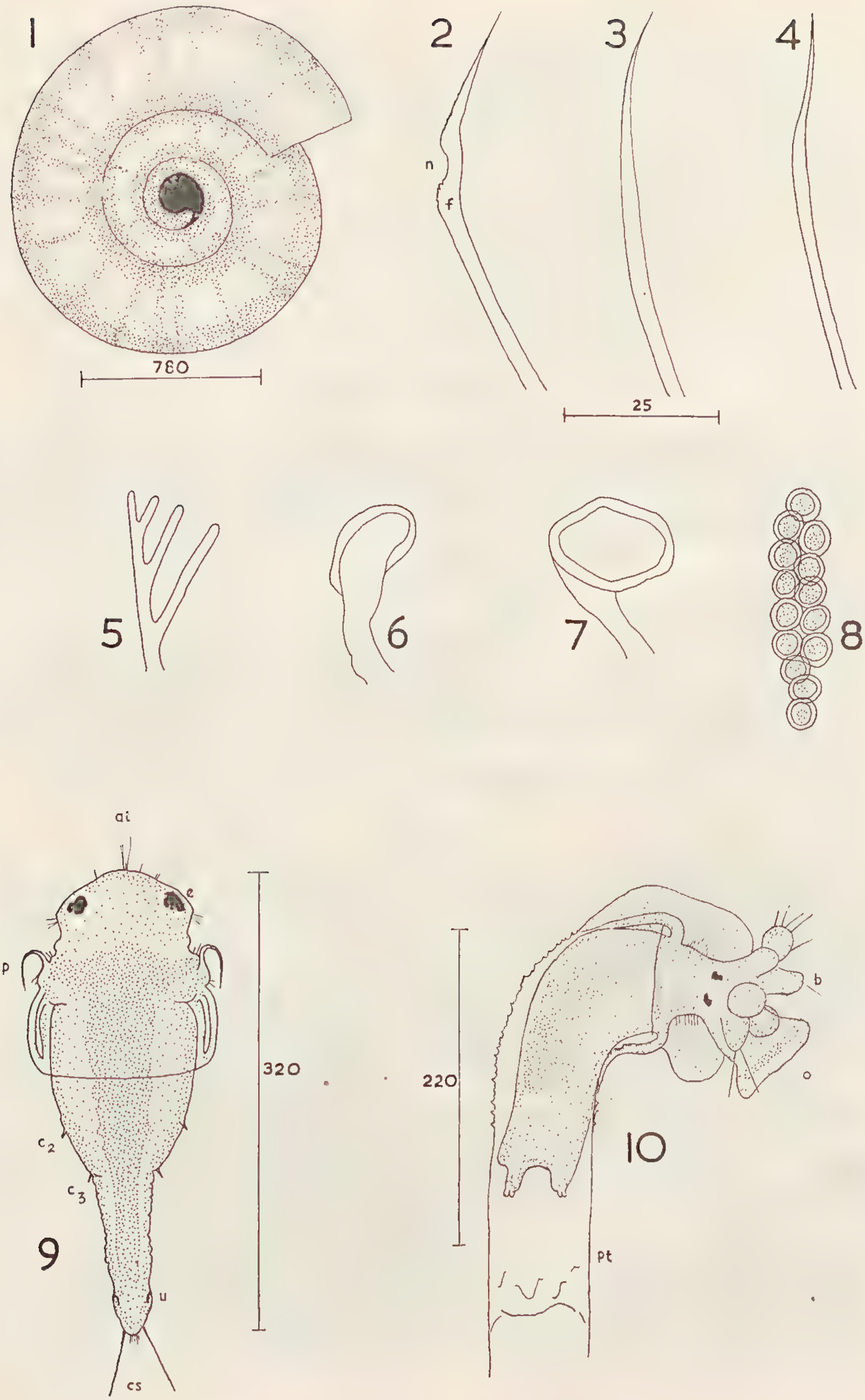
EXPLANATION OF FIGURES

Figs. 1-10.—*Spirorbis convexis*: (1) tube, (2) dorsal seta from first thoracic segment, (3) dorsal seta from second thoracic segment, (4) dorsal seta from third thoracic segment, (5) tip of branchia showing blunt terminal filament, (6-7) side and plan views of operculum with calcified area stippled, (8) egg mass *c.* 1·0 mm. length, (9) larva, (10) young adult 24 hours after attachment. At = apical tuft, b = branchia, c_2–c_3 = setae, *cs* = caudal setae, e = eyespot, f = fin, n = notch, o = operculum, p = prototroch, pt = primary attachment tube, u = uncini. Camera lucida, scale in mμ.

Figs. 11-18.—*Spirorbis lamellosa* Lamarck 1818: (11) tube, (12) dorsal seta from first thoracic segment, (13) dorsal seta from second thoracic segment, (14-15) side and plan views of developing operculum with calcified areas stippled, (16) mature operculum containing eggs, (17) larva, (18) young adult 24 hours after attachment. C = cup, s = slit, sg = thoracic " shell " gland; other abbrevations as in Figs. 1-10. Camera lucida, scale in mμ.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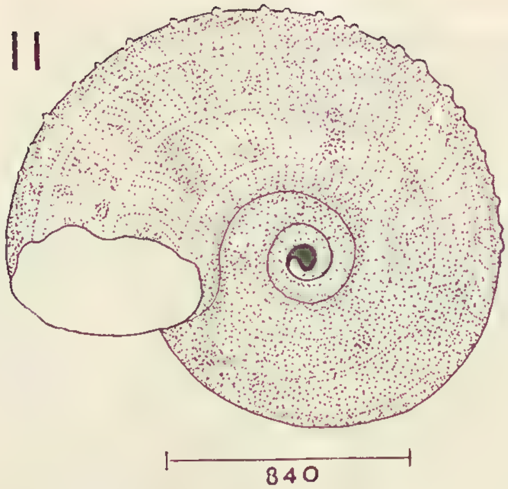

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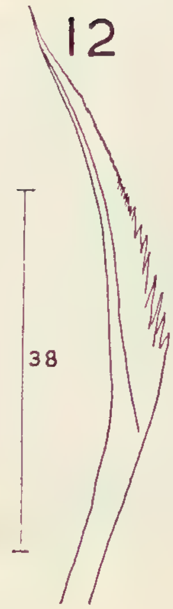

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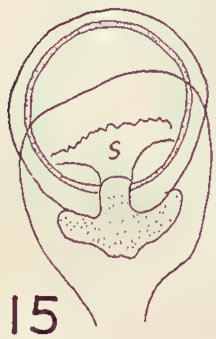

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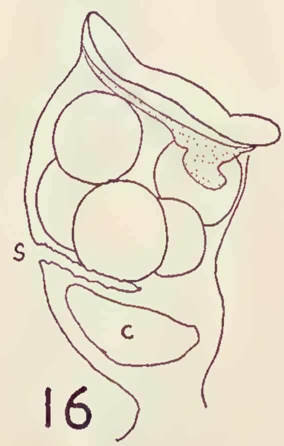

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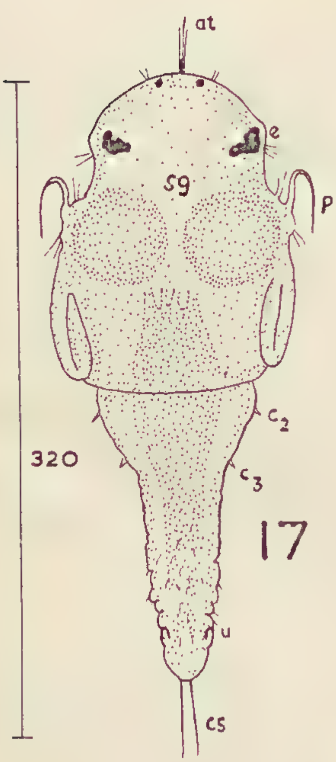

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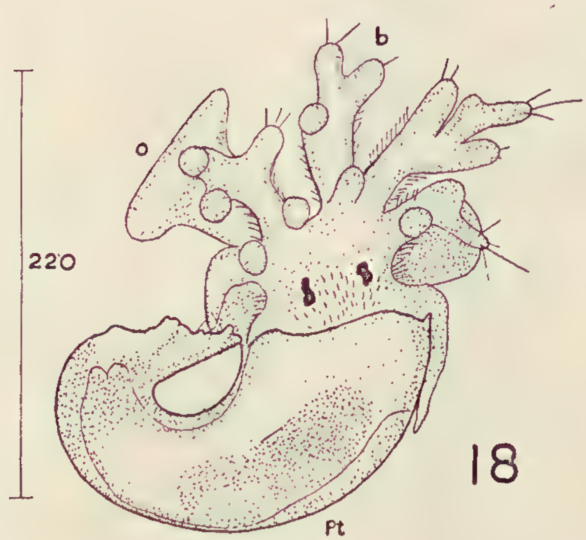

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Sydney: V. C. N. Blight, Government Printer—1962

The Archaeology of Mootwingee, Western New South Wales

BY

F. D. McCarthy,
Australian Museum

and

N. W. G. Macintosh,
University of Sydney

(Figs. 1-9) (Plates XIX-XXVII) Manuscript received 20.9.61

PREVIOUS LITERATURE

The rock engravings in the main gallery, and the paintings in the " Big Cave ", have been described briefly, and some of the main carvings and paintings illustrated, by Pulleine (1926), Riddell (1928), Barrett (1929 and 1943), Davidson (1936), Black (1943 and 1949), and McCarthy (1957 and 1958). Pulleine's claim (op. cit. 80) that he recorded all of the motifs at Mootwingee is far from being the case. These papers indicated that Mootwingee was an important comparative site on the eastern extremity of the full intaglio pecking technique, and a complete recording was therefore decided upon.

CURRENT WORK

One of us (F. D. McC.) assumes total responsibility for the sections on " Pecking Methods, Patination and Antiquity, and Affinities of Paintings and Engravings."

One of us (N. W. G. M.) assumes total responsibility for the map and topographical descriptions and for the sections on " Dingo Rock and Mythology of Mootwingee according to George Dutton ".

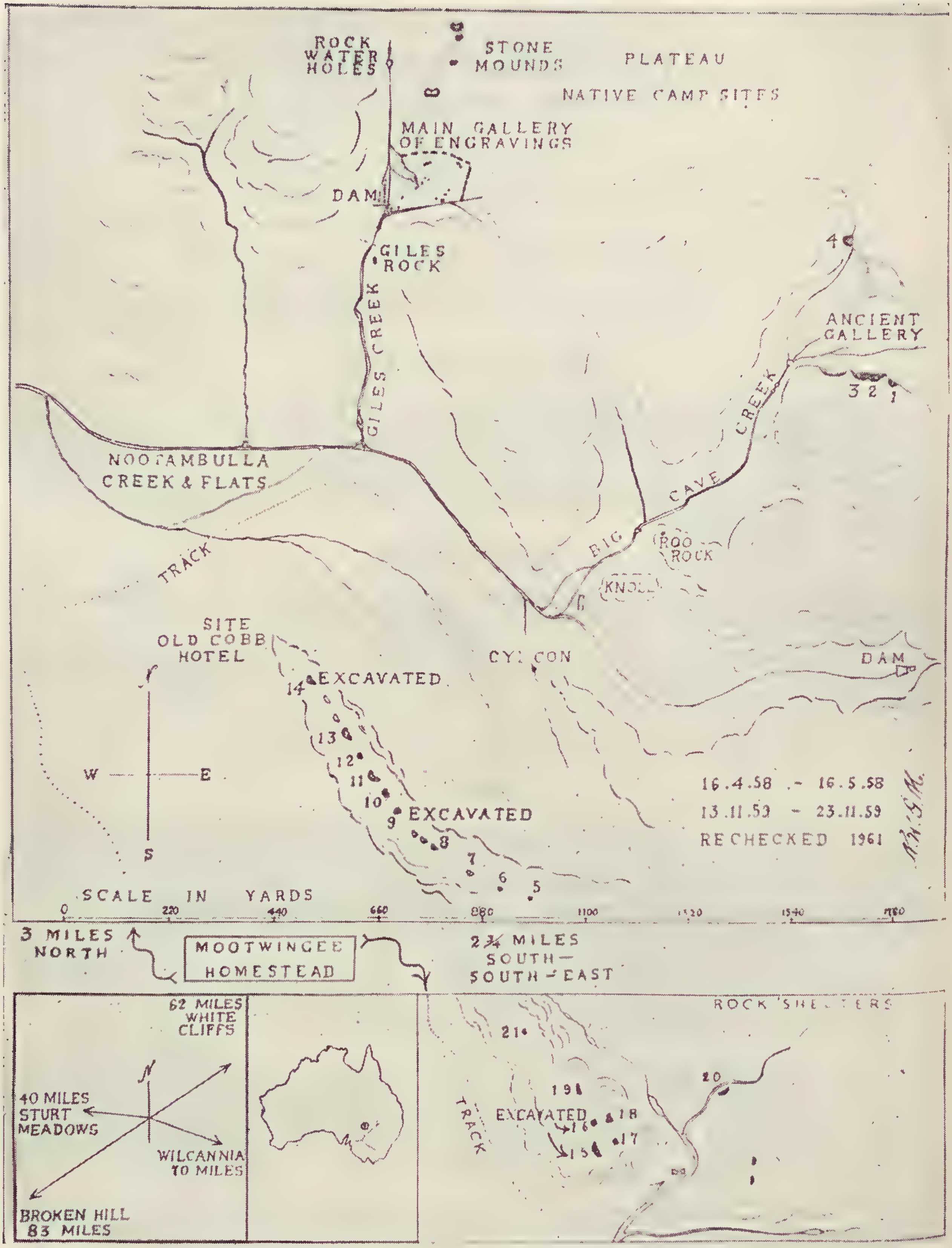
The remainder of the paper, the first draft of which was prepared by F. D. McC., is dual.

HISTORY

It is probable that Wright, the third in command of the Burke and Wills party, who was added to the expedition at Menindee because of his wide knowledge of the country to the north, was the first white man to see the strange markings on the rocks. The route of the expedition passed Mutwongee (as Wills recorded the name originally) on October 16th, 1860, and although Wills mentioned the existence of permanent water there he did not refer to the engravings. Ernest Giles used the valley in which the carvings are situated as a regular camping place, and left inscriptions (discovered by Mr. A. Morris in 1921 on a tributary of Nootambulla Creek) recording his visits in July, 1861, and August and September, 1863. Dow (1937) accepted the probable authenticity of Giles' inscriptions. Howitt's relief party followed the same track in 1861, and it was thereafter used by all travellers to the north from Menindee and the Darling until pastoral development of the Broken Hill district began in 1866.

As the main gallery of engravings is only a furlong from Giles' inscriptions, both his party and many other white men must have seen it between 1863 and 1890, as it is right beside the rock-holes from which travellers drew water in this valley. There are no historical reports by the early explorers or subsequent travellers of natives or native ceremonies at these sites. The old coaching-days hotel, built about half a mile away, also drew water from these rock-holes which were dammed with concrete for the purpose.

The early white settlers drove the natives off their traditional country to ensure undisturbed grazing for sheep and cattle. Such an antagonistic attitude did not encourage interest in the Aborigines, and little has been recorded about the rock art and religion of the far western tribes. Dr. MacGillivray, of Broken Hill, was the first naturalist to take an interest in the Mootwingee site, to which he took Dr. Pulleine, of Adelaide, in 1935, and the latter's brief paper appeared a year later.



Text Fig. 1—Map showing total Aboriginal sites at Mootwingee Reserve described in the text.

The presence of permanent water in the numerous rock-holes (not as now despoiled by goats, sheep and horses) must have been a valuable asset to the local groups of Aborigines in the vicinity of Mootwingee. The tribe was called the Bulalli by Howitt (1904, 49), the Wilyakali by Tindale (1940, 195, map), and the Bandjigali by Beckett (1958, 92). As Bonney pointed out (1883, 2), the country in its natural state could not support a large population, being subject to periodic droughts of which he experienced three lasting from 18 to 22 months in 15 years. During these droughts, he said, the surface waterholes dried up, and the natives camped at the springs or rivers, existing on the half-starved animals which were killed without much difficulty. The country had a desert-like appearance, relieved by sundry hardy bushes and small trees which somehow held up against the extreme dryness and hot winds. Bonney (op. cit.) said the long droughts were generally broken by a fall of two or three inches of rain, followed by lighter rains, which rapidly improved the appearance of the country, the waterfowl returned in large numbers to the creeks and billabongs, and the Aborigines moved on to fresh hunting grounds. Keast (1959) has postulated that the breeding rhythms of animals are deferred until a drought is finished, and many birds migrate out of the stricken areas. After a series of good seasons, the rock-holes and pools in Nootambulla Creek contained an abundant supply of water in 1955, but since then there has been a series of dry seasons and (apart from the rock-holes dammed with concrete walls) very little water available in the natural rock-holes, and none in the creek bed in 1959.

Bonney estimated the average native population of far western New South Wales to be 100 persons to 2,000 square miles, an area that would cover the Mootwingee reserve and the surrounding country for a radius of about 20 miles. It is apparent, therefore, that the 21 caves of paintings, the main and other galleries of engravings, and the numerous camp-sites must have been the work of many generations. The 1883 census of the Aborigines Protection Board stated that there were more than 300 natives in the vicinity of Tibooburra, and probably more on outlying stations. In 1915, there were no more than 50 natives in the same area (N.S.W. Govt. Papers, 1883-1915).

Beckett (1958, 93) said that the last initiation ceremony of the Bagundji (south of the Bandjigali) was held in 1904, and the last Milia rite in 1914 ; that no Aborigines under 40 can now speak their language, and there are none living who can recall the coming of the white man. Remnants of the various tribes now live in Wilcannia, but they are also scattered from Tibooburra to Bourke and Brewarrina.

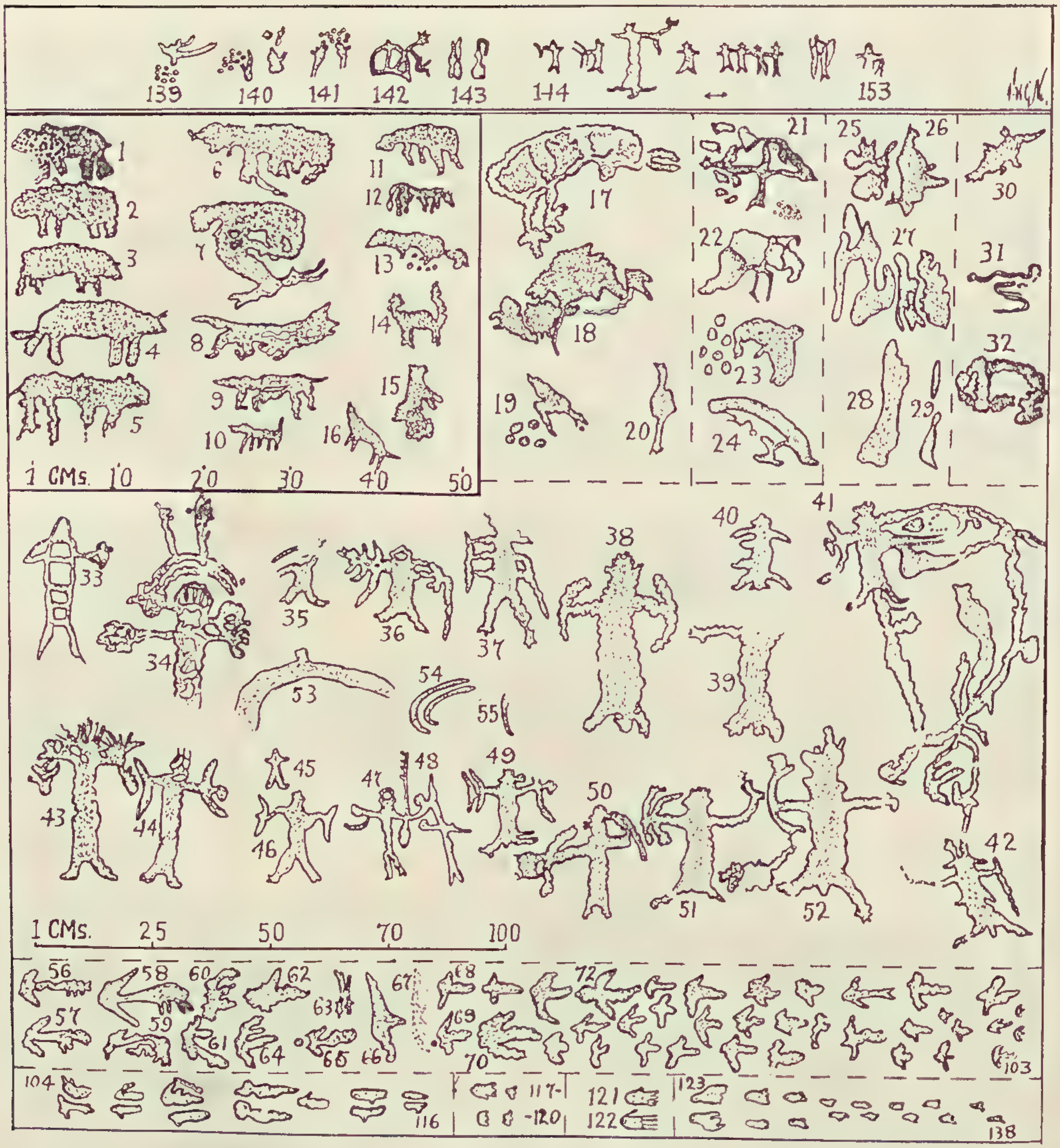
The Bandjigali (Beckett, 1958, 92) were probably " organised into inter-tribal patrilineal clans, ceremonial groups supposedly descended from a *mura* ancestor who once travelled, naming and forming the country as he went ". These clans extended across tribal boundaries into the Maliangaba, Wonggumara and Gunggadidji tribes. Some of these sacred *mura* tracks go from the White Cliffs district up to Bulloo Downs, others stretch from the Paroo to Lake Eyre. Matrilineal moieties of Eaglehawk and Crow are general in this region (Radcliffe-Brown, 1931).

GEOGRAPHY

The map (q.v.) indicates the topographical relationship of the galleries and accessory sites of rock engravings, the 21 caves which contain stencils and paintings and/or engravings, the four caves possessing floor deposits which were excavated, four stone mounds and surface sites where implements were collected on the Nootambulla Creek flats and on the plateau which bears evidence of native camp-sites. The presence of so many facets of Aboriginal activity makes the site a valuable one for correlative analysis. Each of these facets is described. An area of 18,840 acres was proclaimed Reserve 59533 for the preservation of caves at the request of the Broken Hill Field Naturalists' Club in 1927. The map shows that the Mootwingee Reserve is 83 miles north-east of Broken Hill, 62 miles south-west of White Cliffs and 40 miles almost due east from Sturt Meadows engravings. The Broken Hill-White Cliffs road passes within a mile of the western side of the Reserve. Lithgow (1961) has described the natural history of the area.

The caves and galleries occur among a series of ridges and hills which are part of an extensive dissected plateau of ancient massive sandstones, quartzites and conglomerates. The valleys are flat-floored, narrowing into gorges or canyons at their heads or into long steep slopes of rock. Large rock holes from 10 to 30 feet across have been waterworn into these slopes in the course of time, and some hold water permanently.

For descriptive purposes the creeks traversing two of these valleys have been arbitrarily named Giles Creek and Big Cave Creek, the former because of an inscription purporting to have been made by the explorer, the latter because the largest stencil cave at Mootwingee is near its headwaters.



Text Fig. 2—The motifs shown in the mass composition in Plate 2 have here been extracted and segregated into dingoes, emus, (? birds), unidentified objects, reptiles, men and material culture, emu tracks, wallaby or kangaroo tracks (hind and fore), human hands and feet. The top series, Nos. 139-153, located near the apex of Dingo Rock and not shown in Plate 2, are separated from the other motifs by a sterile strip of rock and are considered to belong to an emu composition on an adjacent slab. They are much smaller in size and different in type. This is one criterion for believing the fracturing of the gallery into slabs occurred after completion of the engravings. Scale is approximately the same for all figures except the Dingoes, where it is approximately x 2.

Both these creeks flow into Nootambulla Creek commonly, but wrongly, known as Mootwingee Creek. The creeks are fringed with white gums frequented by white cockatoos, galahs, crows, magpies and other birds. A variety of acacias, including beefwoods, grow among the pines and other trees and bushes on the rocky slopes adding an attractive note of green to the general reddish-brown of the rock formation. Possibly the flats were covered with mulga and other vegetation prior to white occupation.

The stone of the galleries is usually white when freshly broken, but tints ranging from pink to reddish-brown and dark brown are exhibited on weathered surfaces according to the degree of oxidation and the content of iron oxides (Kenny, 1934, 54). Some surfaces are blackened by a resinous gum shed from beefwood trees growing in crevices beside them. Mitchell said the blackened surfaces were due to the deposition of limonite, a hydrated oxide of iron. Damp, decaying vegetation has probably played a part, too.

The sandstone is merely the skin of a conglomerate of waterworn pebbles which are exposed in many places and weathered out of the formation in great numbers. In places like the Main Gallery the massive sandstone is laminated and broken into flat-sided slabs up to several feet thick. Almost all the engravings occur on fine-grained, sand-polished surfaces.

The Main Gallery of Engravings is situated on a rocky slope between a steep narrow valley containing the head of Giles Creek on the west and another narrow tributary on the south-south-east. Its long axis is 190 yards and its traverse axis 60 yards ; it slopes upwards from the south-west to the north-east at an angle of about 20 degrees. At its base is a deep waterhole, and 50 yards further north a dam, constructed to provide pipe supply to the old hotel, marks the site of a former waterhole now silted up.

One small and two more large waterholes occur up to 250 yards further north. All are replenished by drainage from the higher slopes at the head of Giles Creek Valley. It was up Giles Creek that the *mura* Kulabiru (Syn : Kwilabiru, Guluwira) walked on his journey from the south, and each of the waterholes was made by his footsteps ; as each was made he cried *kokaru*, i.e., the hole, and in each subsequently there grew a *ngaitchi*—water snake. This is according to our informant, Mr. George Dutton, who as a lad was taken by his father up this creek in the pathway of Kulabiru.

The present surface of Main Gallery is fractured into rocks of all sizes, and many flat-topped slabs lie loose on the surface or in large crevices created by the breaking-up of the outcrop in the past. Practically every suitable rock surface on this slope bears engravings. Smaller series of engravings are to be seen within a quarter mile to the south and south-east. A small number of figures was found on top of a high and isolated outcrop (knoll) near the junction of Big Cave and Nootambulla Creeks. Engravings of human and other figures occur here and there on the walls of Giles and Big Cave Valleys, and in particular a large kangaroo (Roo Rock) on a spur south-east of the lower portion of Big Cave Creek.

An old and now almost weathered-out gallery apparently existed on the slope north of Big Cave (Cave 2), and another on a small slope above Main Gallery.

ENGRAVINGS

A feature of the engravings is the use of topographically quite widely separated rock surfaces for the portrayal of different subjects and distinctive compositions. These can be grouped as follows :—

Plate XX illustrates one large rock and two adjacent sections of rock devoted to an intermingled collection of repetitive motifs, including a most ornately decorated humanoid figure with elaborate head-dress, undoubtedly a Cult Hero, perhaps a *mura* ancestor, men moderately decorated and/or heavily armed, and men undecorated and lightly armed. Associated with representatives of each of these is a mammal-like figure tentatively identified as a dingo ; hence this section of the gallery has been arbitrarily called Dingo Rock. Among four or five emus is a large, banded, distorted one, only partially pecked, but with deeply grooved outline, and apparently it is older than the others. There are also separate boomerangs, human tracks, kangaroo tracks, emu tracks, many emu eggs, a large coiled snake and a goanna. The site is half-way up the south-eastern edge of the Main Gallery. It will be described separately further on.

Plate XXI illustrates five examples of the repetitive portrayal of a single motif on a separate rock surface. The first shows an assemblage of some 20 men armed with spears, boomerangs and spearthrowers, one unarmed man beside a double-tailed concentric circle, and a kangaroo. The armed men are of three sizes—larger, intermediate, smaller. They suggest a kangaroo-hunting party. Instead, our informant, Mr. George Dutton, identified the group as a rain-making party ; the outer circle represents the waterhole, the inner circle the pile of coolamons containing each

Text Fig. 3—1. Varieties in human portrayal. Note the lack of standardisation of type. 2. Series of female figures. 3. Human feet and hands. 4. Wind breaks. 5. Feather plume ornaments. Figures from 4 to 12 inches long.

man's fire-burned rain-stones, blood and feathers ; the unarmed man is the one who goes into the waterhole to place and hold the coolamons in position ; the two tails of the circle represent the track where the rest of the party walk in to stand on the first man's shoulders and hold him down while he arranges the coolamons. The kangaroo is part of the reason for the rain-making ceremony. This rock of the " Rain-makers " is situated in the middle of Main Gallery.

The second photograph illustrates little men 6 in. tall wearing very tall turret-shaped head-dresses or masks from 1 ft. 6 in. to 4 ft. 6 in. high, which are decorated with bars, and three of them include rounded dots (? emu eggs) and kangaroo and emu tracks. These head-dresses provide proof that ceremonies were carried out at this site. Our informant, Mr. George Dutton, identified them as *kungulada*, that is, tall hats, for the emu corroboree which was operative at Nockatunga in his youth and diffused down to Tibooburra prior to its extinction This rock of the " Tall Hats " is situated near the apex of Main Gallery.

The third photograph presents 12 tiny female figures ; some are wearing either a plume-like forehead band or long hair shown in radiate fashion. Three of them have thin stick-type bodies and limbs, others thick heavy bodies, and one an anvil-shaped body. One has curved and upraised arms like a flying bird, and one is surrounded by a circle of dots. Each has a vulva greatly exaggerated in relative size and represented by a circle with a central dot. There is one representation of the vulva alone ; if taken out of context with the female figures it would probably be interpreted as a flying object. There are six emu tracks, a clutch of eggs and three sets of small parallel curved lines. Only one other engraving of a woman occurs on Main Gallery. It is on Dingo Rock and portrayed in quite different style. (Text Fig. 2, No. 40.)

This rock of the " Little Women " is situated below the base of Main Gallery on the left bank of the bed of Giles Creek. It suggests a dreaming place for human reproduction, or one connected with women's ceremony. The frequency of the emu egg motif suggests that the women may have visited the Main Gallery and participated in some ceremonies with the men. In any case, they probably drew water at the site of this rock. Millstones and mullers, mortars and pestles were collected on camp-sites along both sides of Giles Creek and at the base of the rocky slopes of the valley to within a furlong of the Main Gallery. These are used by women among all Aboriginal tribes, so it can be assumed these camps were occupied by mixed groups.

The fourth photograph shows the vertical rock face in a creek valley engraved with nine examples of barred, hollow-bodied men. One is wearing a ritual head-dress. Boomerangs singly and in pairs are engraved on the same rock face. Only three other instances of the hollow-bodied barred man (Pl. XXIII, No. 8, Pl. XXII, No. 6, and Text Fig 2, No. 33) occur on the Main Gallery.

The fifth photograph shows an isolated rock at the south-eastern base of Main Gallery. Its surface bears innumerable engravings consisting solely of a complex design of tracks, including large and small kangaroo or wallaby, fore and hind limbs, goanna, emu and other birds and probably snake and insect. Our informant, Mr. George Dutton, identified this rock as portraying an incident from the Eaglehawk-Crow myth in which the crow, having killed the hawk's son, then set to work making a maze of tracks to deceive and foil the hawk which was out hunting. When the hawk came along he was completely baffled by these tracks and failed to catch any game. This set the scene for a further series of incidents in which the hawk was killed by the crow but revivified by the spider. The crow was subsequently buried but escaped from the grave, only to be trapped in a burning shelter from which he also escaped burnt black.

In contrast with Plate XX, which illustrates a massed composition of several motifs on one particular area of rock, and with Plate XXI, which illustrates the repetitive engraving of a single motif on isolated rocks geographically widely dispersed from the others, Plates XXII and XXIII illustrate the repetition of a particular motif throughout the entire Main Gallery and beyond it. Plate XXII illustrates the dominant frequency of the emu egg motif ; Plate XXIII indicates the less frequent but still very prominent kangaroo motif and also some styles of human portrayal and weapons.

In further contrast, Plate XXIV shows motifs which are scarce at Mootwingee and occur sporadically through the galleries.

Subjects

Compositions : It is uncertain whether a mixed series of figures represents a composition or just an accumulation of odd figures on a favourable rock. Crowding of a rock with a preponderance of similar combinations, as in " Dingo Rock " (Plate XX), makes a composition seem more likely. But real difficulty in interpretation is presented by a rock (Plate XXV, No. 1) which has been photographed more often than any other engraved surface at Mootwingee ; it bears an assortment of boomerangs, a pair of kangaroo tracks as big as a little man beside them, a comparatively big lizard, a clutch of eggs and other figures. This may or may not have been a grouping in the eyes of the artist, but the figures, which are in the same technique and state of

Text Fig. 4—The full range of variation of (1) emu tracks: (2) kangaroo tracks: and (3) shapes. Note particulary the emu track (3rd line, centre) with the heel pad and three toes clearly separated and that it is smaller in size than many others not so portrayed.

preservation, are so carefully placed beside one another that a composition illustrating a legend is strongly suggested. The crossing of the large and perfectly represented tracks of kangaroos and emus (Pl. XXV, No. 2) may represent a favourite hunting ground where the animals are always to be found—a popular theme in Arnhem Land art. Further simple compositions may illustrate rites conducted at Mootwingee as well as hunting activities carried out in daily life. A major proportion, at least 20, are concerned with the emu, its eggs and its tracks. Fourteen of these are shown in Plate XXII. From above down in three columns from left to right are seen : Two armed hunters beside an enclosed nest ; a hunter, two clutches, two circles (tailed), three emu tracks crossing one of the circles ; a hunter in the middle of four nests ; two men fighting beside a nest ; two boomerangs and two tracks between two clutches ; four men (one barred) grouped round a boomerang, two tracks and three clutches ; an unarmed man, a clutch, two crosses, a half-barred semi-circle and barbed line ; three scattered boomerangs, a tiny headless emu beside its nest, two additional clutches, three shanks and two lizards ; two clutches of eggs and three tracks ; one clutch between two large emu tracks with another nearby, indicating by the position of the tracks that the bird is nesting ; a clutch within a rough circle ; an emu rearranging one of three clutches, some scattered eggs and a boomerang nearby which may have been thrown at the bird ; an emu sitting on its clutch ; a large emu inspecting a nest. On " Dingo Rock " (Plate XX and Text Fig. 2, No. 18) chicks are shown with an emu. Near the apex of the gallery are two emu hunts ; other rocks display up to six sets of emu eggs. These main compositions are not repeated, but throughout the gallery occur emu tracks and emu eggs ; it is rare for any engraved rock not to include an emu pad. Although there are not many figures of the actual bird, it is significant that four are rearranging clutches, one is sitting on a clutch, two are standing beside clutches, one is inspecting a clutch. These compositions, plus the relation of emu tracks and clutch, establish that the innumerable clutches, some presenting up to 21 eggs to a clutch, scattered widely through the Main and Ancient Galleries and on isolated outcrops, belong mainly to the emu. It cannot be claimed with certainty that all clutches are emu, as sets occur in company with goanna or lizard and perhaps a flying bird (Pl. XXII., Nos. 8 and 12), but this is a unique combination at Mootwingee and more probably represents emu eggs figuring in an additional episode, e.g., as the objectives of a marauding goanna.

Other simple compositions feature a boomerang thrown at a kangaroo, a kangaroo speared in the back, four armed men beside kangaroo tracks ; a kangaroo hunt is also indicated by a boomerang and two forepaw tracks and by an armed man and a boomerang beside two hind tracks (all in Pl. XXIII). A common feature of Aboriginal art is the representation of hunting incidents by eliminating the naturalistic figures of hunter and animal and simply depicting the weapons of the hunter and/or the tracks of hunter and animal.

Human : The men include the stick type either singly or in small groups (Pl. XXIII.), also round-bodied and heavy-bodied human types (Text Fig. 3). They are shown from the front with rounded and peaked heads, the neck not defined, and the arms usually horizontal. Fingers or toes are very rarely indicated, and the penis in about 20 per cent. of cases. There is no absolute standardisation of type as with the painted Mimi of western Arnhem Land. Many of the men hold one to three boomerangs in either or both hands. Some carry a spear with three or four barbs on one side and a spearthrower, and one little man is carrying both spear and boomerang. Several unusual figures merit comment. One is a stick-type man carrying a club or spearthrower from the bottom of which a long curved line extends below the figure. Another is the hollow-bodied barred type already described (Plate XXI). In cave 4 (Text Fig. 7, top right) is a man standing on one leg, a figure unique in Australian rock art. Although crudely made in the coarse wall, it has a grace of posture unusual in Mootwingee art.

The largest unarmed human figure, almost 1 ft. high, is depicted in a simple rounded style which tends towards a conical form from feet to head (Pl. XXIII, No. 11).

Mammals : The dominant mammal in the gallery is the kangaroo, of which there are four comparatively large figures from 2 ft. to 6 ft. long, and three smaller ones from 8 in. to 1 ft. long (Plate XXIII). In the intaglio figures, the smallest one lacks tail and hind legs but has large forepaws; one has very big hindlegs and no forelegs ; one has a curious lumpy extension of its forelegs; one has a very thick tail and ill-defined forelegs ; and one is well proportioned and in a hopping posture. The largest figure of a kangaroo (Pl. XXIII., No. 3) is engraved on a long low spur on the eastern side of Big Cave Creek (see map). It is just over a furlong from Nootambulla Creek. This kangaroo has a heavily pecked outline and a pattern of lines on the forepart of its body ; the whole of the tail is pecked into a full intaglio ; the body is only lightly pitted here and there. It may have been the intention of the artist to peck the body all over ; alternatively, it is an old figure which another artist began to make into a full intaglio in a later generation. This kangaroo has one short and one long hind limb, three and six digits on the forelegs, and a pointed nose. The pose is a static one, although the animal is standing in the halfway-up posture characteristic of kangaroos. Part of the rock has broken away, leaving incomplete the posterior part of the figure.

Text Fig. 5—1. Emu egg motifs, up to 3 ft. long: 2. Outline and linear designs, up to 2 ft. long.

Two of the mammal figures are difficult to identify. Both are probably bandicoots, of which they are, however, unusually large representations, 3 ft. and 4 ft. 4 in. Another pair of small mammals (Pl. XXIII) may be bandicoots, wombats or native cats, and a small figure 15 in. long, with a short tail, is probably a possum. Three toes are commonly shown on the mammals. A series of 16 dingoes (sic) is described in the section dealing with Dingo Rock.

Birds : The emu is practically the only bird in the engravings and has been fully described under Compositions.

Reptiles : The only engravings of snakes are the two on Dingo Rock. Several engravings of lizards were found. Two in the main gallery are simple linear figures (Pl. XXII, No. 8) lacking digits. One of them is posed beside a set of eggs. The nest may be its own, but as the other lizard is surrounded by 20 emu tracks the nest may be an emu's. A short broad species of lizard like a gecko, and a goanna, are depicted in the main gallery, and the shelly-backed lizard, a short, thick and scaly type, is shown in a now patinated and waterworn figure in the bed of Big Cave Creek, near the first pothole at the base of the long slope leading up to the cave. Barrett (1929) referred to tortoises ; we could find no such engravings, although the habitat of the tortoise (Chelodina) includes this region.

Fish : There are no actual fish engravings, but two tailed circles, which might possibly have been derived originally from the stingray motif, and broad double semi-circular designs (Pl. XXIV, No. 14) which represent the stingray's liver in northern Australian rock art, constitute unusually interesting motifs at Mootwingee. Note, however, that Dutton identified one of these double-tailed circles as a rain-making rock-hole. These identifications will be discussed further under Affinities.

Tracks : Three kinds of tracks are represented, the human, emu and kangaroo. The full range of variation is shown (Text Fig. 4). The human tracks are full intaglios in different sizes, occurring only on Dingo Rock. It is impossible to distinguish between the tracks of the kangaroo, euro and wallaby, and most of them will be referred to as kangaroo in this paper. In one instance the forepaws and tail (the hind foot tracks have broken away on the side of a fissure) are shown as a unit, a motif not previously recorded as an engraving in the interior of Australia but a common one in north-western Australia. McCarthy in 1958 recorded many examples of it at Port Hedland (Manuscript) and on Depuch Island (1961). Some of the double tracks represent either the emu or kangaroo. There are both thin linear and thick broad intaglio engravings of both kinds of tracks. These tracks occur singly, in pairs, in lines, in groups, intermixed, and frequently as part of compositions. They are to be seen in large numbers throughout the entire gallery.

Plants : There are two engravings of a plant bearing rounded fruits, berries or nuts. One of them (Pl. XXIV, No. 1) occurs at the base of the rock slope leading up to the Big Cave from the creek below it. It has 19 pecked spheres on a vine-like plant. Another similar design (Pl. XXIV, No. 6) in the main gallery has fruits or berries on the ends of straight stalks attached to a sinuous central stem. The crop from these plants, which may be the kangaroo berry, was probably gathered by the women. One design (Pl. XXIV, No. 4) resembles the grass-tree.

Material Culture : The boomerang is the only weapon engraved separately. Spear, spearthrower and club are not engraved separately but are held by men. The boomerangs include a long slender type, probably the tooled mulga type (McCarthy, 1957, p. 78, fig. 1) typical of western New South Wales. There is also a broad type of medium length. The boomerang is shown singly, and in vertical sets of two, three and four (Text Fig. 6). An oval barred figure (Text Fig. 7) may represent a sacred board or shield. The spears bear from one to four barbs in a single row. Davidson (1934, Figs. 2, 10) recorded the use of plain-headed spears, and spears armed with one row of barbs, on the Darling River, and it is obvious that the latter type was used as far north at Mootwingee at least. The type of spearthrower is not clearly defined, as it is carried by tiny figures of men and is usually shown as a simple stroke or crescent (Text Fig. 3). Two engravings resemble a windbreak, one occupied by three adults and a child or dog, the other by two adults lying in the shelter (Text Fig. 3, No. 4).

Four small figures appear to represent the feather plume ornaments made by binding and gumming the feathers of cockatoos or other birds on to a spike which is thrust in the hair or through an armlet. (Text Fig. 3, No. 5.)

Circles : Such motifs are scarce at Mootwingee, and tend rather to oval shape. Only one thin outline circle, and several tailed circles were found. Within the outline of some ovals are engraved a kangaroo fore track (Pl. XXIV), a pair of kangaroo hind tracks in fine line (Text Fig. 5), a full intaglio emu track (Pl. XXII, No. 2) which may be fortuitous, a clutch of emu eggs (Pl. IV, No. 11), a pair of dots (Pl. XXIV, No. 15), while one has a short line at one end, one band from one side to the other, and two have tails (Pls. XXI and XXIV).

Text Fig 6—1. Artefacts. 2. Cave paintings, various sites. 3. Pecked designs. Figures from 3 to 18 inches long.

The ovals occur singly, in pairs and in threes. There is only one example of a concentric circle, which has a conical projection like the handle of a ceremonial object. Pulleine (1926, 180) said he saw a faint spiral on the vertical rock face, but we did not find it.

Radiate : Four splendid radiate figures were found, three of them in the main gallery and one among a smaller patch of figures a quarter of a mile to the south-east. The largest one (Pl. XXIV, No. 7) has 17 rays, most of which have a rounded knob, and one an emu track, at the end, and the design appears to be connected in some way with this bird. It is tempting to think that each knob represents an egg or nest, but there are so many other possible meanings, including sacred rites, waterholes or camps, that any interpretation is problematical. Other smaller examples of this design have seven knobbed rays and one plain but bent ray (Pl. XXIV, now in the Australian Museum), six knobbed and two plain rays (Pl. XXIV, No. 9) and two knobbed and six plain rays (Pl. XXIV, No. 8).

Designs : Many of the linear figures and complex designs can neither be adequately described nor interpreted. Among them the two crosses and the set of parallel lines are the only widespread motifs in Australian rock art. There is a limited number of designs in both the linear and pecked band styles, and many of the latter are unique to Mootwingee. The presence of unique local designs appears to be characteristic of pecked-engraving sites generally.

Irregular Shapes : (Text Fig. 4). Scattered throughout the site, and often forming part of compositions, is a large number of irregular shaped intaglios which appear at first sight to be attempts by novices to make an engraving. They seem to be completed figures which represent ridges, hills, lakes and other features of the landscape mentioned in the legends. They occur in other sites of pecked engravings, but have not previously been noted or recorded.

DINGO ROCK

(Plate XX and Text Fig. 2)

Description of the Rock : This rock is located half way up the south-eastern margin of Main Gallery, above the ravine of a tributary of Giles' Creek, It is a slab of sandstone isolated from neighbouring slabs by 1.0 metre deep crevices which vary in width from 0.3 to 1.5 metres. It appears to be resting, like its neighbours, on an unfractured substratum of sandstone and in a plane approximately 20° from the horizontal. It is uniformly 1 metre thick. Stratification layers varying from 10 to 20 cms. in thickness can be seen in its western lateral or fracture faces, and testify to its sedimentary origin. Its eastern lateral faces are more rounded and matured by weathering. It is rhomboidal in shape, the longitudinal axis bearing 40° measures 5.0 metres, and the transverse axis 3.7 metres. Each side measures approximately 3 metres.

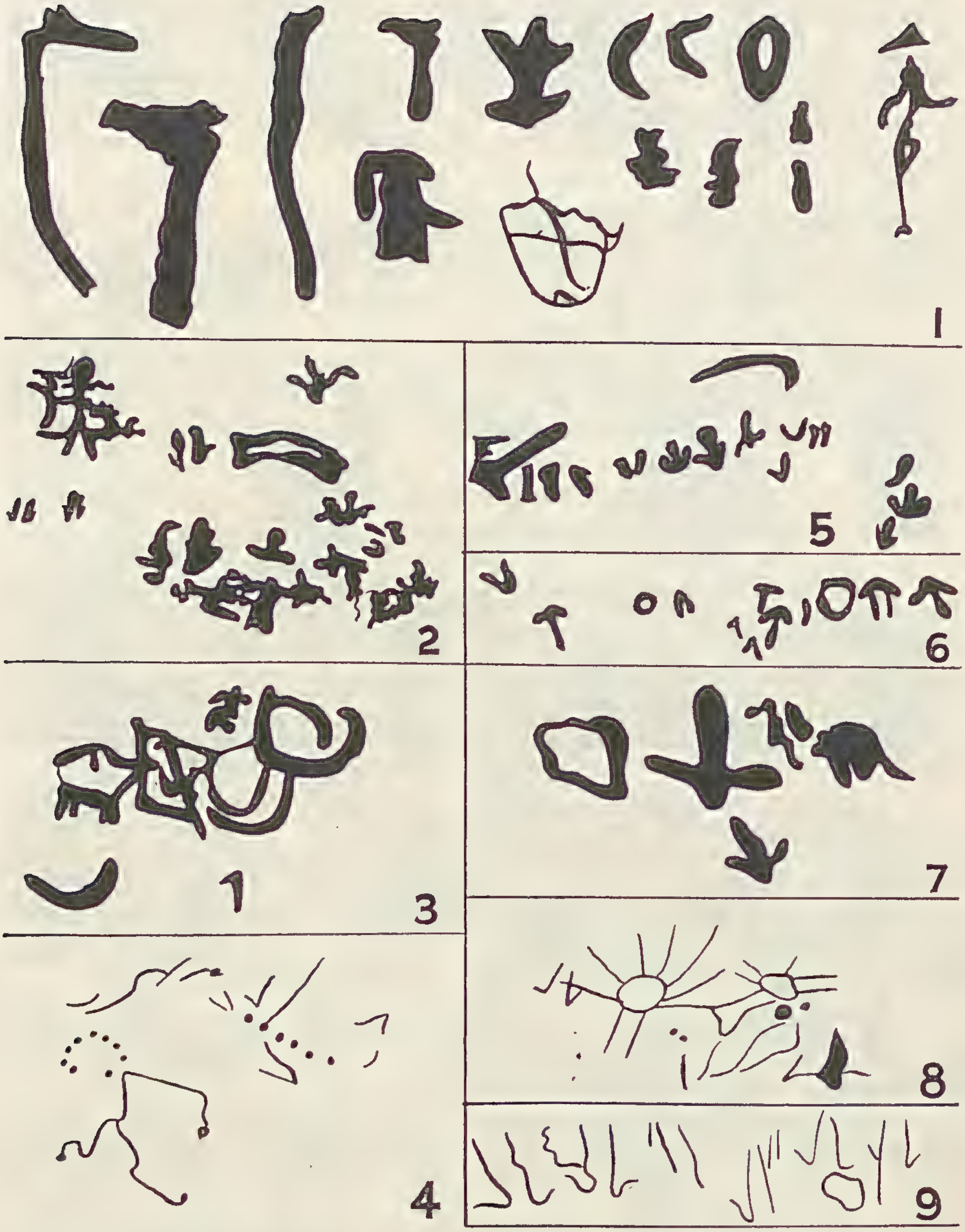
Superimposed on the north-western quarter of its surface is a square block of sandstone, each side measuring 1.25 metres. Its maximum thickness is 1 metre. Lamination is very obvious, and fracture through one of these layers has shed half the block to a depth of 0.5 metre. By calculation, the block weighs approximately 750 kilograms. Two irregular slabs derived from this fractured block lie end-on in the crevice bounding the south-western margin of Dingo Rock. The surface of Dingo Rock immediately adjacent to the south-eastern margin of the block is shattered over an area measuring 10 by 50 cms.; a layer 15 cms. thick has flaked off, carrying away portion of the most elaborate engraving on the rock. It can be assumed this damage was caused by the two irregular slabs when they broke off from the fractured block.

The block is not resting directly on the surface of Dingo Rock. Intervening are six separate squarish slabs 20 to 40 cms. in width and 30 cms. in thickness. The space separating the superimposed block from the underlying surface varies from 15 to 35 cms. and it is possible to insert the full length of an arm most of the way round, under the margins of the block.

The surface thus sheltered feels smoother, less granular, has very few surface fissures, and pecked engravings can be detected by touch on this hidden surface. Their pits can be seen by a torch beam, but what they portray cannot be determined from such an oblique angle of vision.

The superimposed block has rolled, presumably by torrential flood, down the hillside into its present position after the engravings had been completed, and the event was sufficiently long ago for the surface of Dingo Rock to have developed a differential texture in the protected and the exposed regions.

This is strong evidence for the antiquity of the engravings on Dingo Rock, evidence of a kind not observed elsewhere on Main Gallery.



Text Fig. 7—Engravings from various rock shelters. The figures in No 1 are up to 2 ft. long, and the sets of figures in Nos. 2–9 are several feet long.

A luxuriant beefwood tree grows in the crevice at the south-eastern margin and provides a light cover of fallen leaves over the south-eastern quarter of the surface of Dingo Rock. The surface here is blackened and has a very granular weathered texture, and Plate XX shows the striking contrast of this blackened area with the lighter colour of the more western portion of the surface. As the blackening affects the surface only to a depth of one centimetre, the interior of the rock being a light yellowish-grey, it is apparently due to vegetable staining from the shed leaves of the present tree and, presumably, of predecessor trees. The soil in this crevice is a dark loam quite different from disintegrating sandstone and indicates a long period of accumulation of vegetable mould.

The engraved surface is subdivided by fissure fractures into rhomboidal, triangular, square or hexagonal plaques. The fissures vary from 0.5 to 3.0 cms. in width. They are more frequent on the eastern blackened portion and near the apex of the rock, less frequent on the western portion and, as already mentioned, almost absent on the area under the superimposed boulder. The individual lines of fissure fracture number well over 500 and define approximately 200 surface plaques.

In 69 instances these fissures transect engraved figures and in eight instances have resulted in scaling or shedding of an appreciable portion of the figure, in two cases the upper half of a man, in one case the lower half, in one case part of a head, and in four cases most of a boomerang or spear or the hand carrying it. In five cases the distal part of a leg or foot or hand has been carried by the fracture out of alignment with the limb. There are only 15 figures centrally situated within a fissure-surrounded plaque, but in nine of these a pecked connecting line to another group is transected.

Further evidence against post-fissure engraving is the impartial occurrence of the fractures ; the largest and most elaborate figures and the smallest and least pretentious are equally victims. An elaborately decorated Hero (sic) has lost the lower half of his body ; fractures traverse his head-dress, thorax, right arm and one of the mammals beside him. A large banded emu has its beak separated from its body. But also 11 small simple emu tracks are transected. No artist would engrave such a small figure across a fracture, when a change of position of 6 or 7 cms. would provide an intact surface. A further point is that the frequency of engraved figures is highest towards the south-eastern blackened rock surface which also presents the highest frequency of fracture lines ; the less fractured western surface bears fewer engravings. The reverse would be expected if the engravings had post-dated the fracturing.

Plate XX illustrates only the motifs on the lower two-thirds of Dingo Rock, plus similar ones on adjacent surfaces. But on the northern quarter of the surface of Dingo Rock near its apex are sparse engravings representing three clutches of emu eggs, a few emu tracks and two lines of very small dancing men (see Plate XXIII, No. 10, and Text Fig. 2, Nos. 139-153). These motifs are almost certainly to be associated with the emu (Plate XXII, No. 14) on the adjacent rock beyond the fissure which separates it from the apex of Dingo Rock. Below this sparsely engraved area is a blank band of surface area 0.6 x 2 metres in extent. Further south, or inferiorly, the remaining two-thirds of the surface is packed with engravings, prominent among which are decorated or armed men with dog-like animals at their sides. South-west of Dingo Rock on adjacent rock surfaces, but separated from Dingo Rock by its marginal fracture, are two more examples of this motif of decorated or armed men with dog-like mammals (Pl. XX, Nos. 3, 4). In the entire Mootwingee area there are only two other examples which simulate this motif ; they occur in Cave 16, some six miles to the south of Main Gallery (see map).

The sterile area of surface separating the upper and lower compositions indicates that the two series were originally carved on localised areas of an unbroken surface, their separateness of theme being indicated by the intervening sterile strip. This disruption of the figure combinations of two separate compositions is evidence that the engraving preceded also the major fracturing of the rock gallery into slabs.

In summary, there is very strong, and, the writer thinks, conclusive, evidence that the Dingo Rock engravings pre-date (1) the massive fracturing of the sandstone slope into rhomboidal slabs, (2) the widening of the fracture sufficient to permit accommodation for growth of a large tree, (3) the less dramatic fissuring of the surface lamina into rhomboidal plaques, (4) the superimposition of a flood-borne boulder, and (5) the differential weathering and blackening of the engraved surface.

If the length of time necessary to consummate these events of nature was known, a date following the termination of the engraving period could be stated. It is not known, but the most conservative or minimal guess could hardly suggest less than 300 to 600 years, with the possibility that the figure is higher. Hence, the making of the engravings on this rock must have ceased long before the advent of the European.

Text Fig. 8—Stencils of coolamons, lizards, snakes, club, and various unidentifiable objects. Their dimensions are given in the text.

The frequency of fissures in the surface lamina of Dingo Rock is higher than on any other engraved surface in the Main Gallery, but the width of the crevices isolating it as a slab is exceeded in other parts of the Gallery. The surface lamina has a more leached and granular appearance and the actual engravings are more weathered, having less sharply defined edges, than in the larger proportion of other engraved surfaces in the Gallery. Compare, for example, the fresher appearance of rock and engravings in Plates XXI and XXV.

A few examples of barred, banded and incomplete intaglio within a heavily pecked outline occur on Dingo Rock. It is not yet clear whether these are late subsections of a linear phase or early subsections of a full intaglio phase.

While the total engravings of the Main Gallery apparently encompass a considerable period of time, it would seem, all data considered, that the engravings on Dingo Rock were made near the early middle rather than the late limit of that time range.

Some calculations on hypothetical bases : Three hundred and four items are engraved on what has been arbitrarily defined as Dingo Rock. These were chalked in as an aid to identification and to photography. The chalking consumed 14 hours. Recording of the total items in a field survey drawing to scale took eight hours. Using a planimeter on this drawing, it was calculated that the total actually pecked area on Dingo Rock is 1.8 metres, squared.

Using transparent paper, 12 of the dingoes (sic) and the decorated Hero (sic) were traced in outline only. This took two hours. By calculation, tracing the total outlines would have taken 26 hours, some 260 items being smaller than the dingoes.

Three of the dingoes were traced again, each individual peck mark being traced as well as the outline. (This was to assess the range of shapes and sizes of the punctures and gashes.) This took two hours. By calculation, the total group would have involved 100 hours. Many of the peck marks are superimpositions over two or more preliminary layers of pecking ; presumably, if they could all be traced, a factor of x 2.5 would involve 250 hours.

The drawing of Text Fig. 2 by the extraction and re-grouping of motifs from Plate XX took 24 hours, i.e., almost twice as long as chalking in the rock and three times as long as making the field survey copy.

If it is assumed therefore that in making the engravings, the planning, draughtsmanship and design involve a minimal time factor of x 2.5 and that pecking on rock rather than tracing on paper involves a minimal time factor of x 5, then the minimum time to engrave the total figures on Dingo Rock would be 250 x 2.5 x 5 = 3,125 hours.

It is doubtful if the total items on Main Gallery could be systematically and accurately counted. At the most conservative guess there must be 2,500. (Track Rock alone has approximately 600 engraved items.) By calculation, the total engravings on Main Gallery therefore represent some 25,000 man-hours.

As mentioned elsewhere in this paper, apparently the population was numerically small ; but assuming that the making of additional new engravings was a necessary role in annual ceremonies, and therefore assuming that each year 100 man-hours were devoted to engravings, then the total gallery could have been created over a period of 250 years or some 10 generations. Such persistent zeal seems idealistic. Allowing for " stand-still " periods or the likelihood that existing engravings were repecked or simply remained ceremonially adequate for periods of time before additional motifs were needed, then this 250 years might logically need a factor of x 4 or x 5, giving 1,000 to 1,250 years to engrave Main Gallery.

It is difficult to imagine further extending time factors. Long nomadic absence from the sites might risk loss of the engraving technique. Something of that nature may be an explanation for the complete disappearance of knowledge of how the engravings were made.

The Ancient Gallery near Big Cave obviously pre-dates Main Gallery. Comparable figures to the calculations already made would need to be added to assess the beginning and duration of the total (ancient and more recent) engraving at Mootwingee.

Tentative Table Derived from Calculations on Hypothetical Bases from a Study of Dingo Rock

	Minimal	Maximal
Time of cessation of engraving on Dingo Rock	300 B.P.	1,000 B.P.
Period of time occupied in making engravings at Main Gallery ..	250	1250
Time of commencement at Main Gallery	550 B.P.	2250 B.P.
Time of commencement at Ancient Gallery at Mootwingee ..	800 B.P.	3500 B.P.

Text Fig. 9—Stencils and paintings in Big Cave. The snake is 30 feet long.

All calculations employed in this attempt at extrapolation have been aimed at assessment of minimal time. The figures could be over-estimations, but are more likely to be under-estimations.

Factually, it is not known how these engravings were made nor with what, let alone the Aboriginal craftsman's rate of performance ; so the figures calculated above on hypothetical bases may be grossly astray, but they do give some crude evaluation of time involved. It is better to consider hypothetical figures derived from practical considerations, than " stab guesses " ranging from 100 to 10,000 years.

One point is clear : a food hunting community in this region could ill afford such expenditure of energy and man-hours in mere diversion ; engravings must have represented considerable significance to welfare in the population's philosophy.

CENSUS OF SUBJECTS ON DINGO ROCK

Dingo		16
Emu	4	
Emu chick	2	6
? Weather-break		1
Crested Cockatoo		1
? Emu ? boomerang ? bull-roarer		2
Unidentified		8
Goanna		1
Snake		2
Wallaby		1
Humanoid Male :—		
Ornately decorated	1	
Decorated head-dress and armed	5	
Heavily armed and some decoration	5	
Armed but small	4	
Undecorated but armed (large)	1	
Undecorated and unarmed (large), fractured	1	
Unarmed (very small)	1	
Barred	1	19
Humanoid Female		1
? Tree or ? Interconnecting Intaglio Design		1
Boomerangs (separate)		4
Objects held or worn by men :—		
Elaborate head-dress	1	
Ceremonial object (some attached to weapons)	7	
Boomerang	22	
Spear	1	
Spear thrower	3	
Club	1	
? Hand axe	2	37
Emu egg :—		
Clutch—four with total small spheres numbering	35	
Isolated small sphere (egg)	86	121
Tracks :—		
Emu	48	
Wallaby hind	13	
Wallaby fore	4	
Human hand	2	
Human feet	16	83
	Total :	304

Description of subjects as a whole : Plate XX, No. 1., shows the subjects in their correct spatial relationship and with a relatively uniform scale for all. It is a composite picture and involved much difficulty in manufacture. The obliquity of the rock makes it impossible to photograph the entire surface in one frame without distortion to the shape and size of the subjects. A series of photographs of sections of the rock were therefore cut, and enlarged or reduced progressively until they pieced together as a unified whole. The fissure fractures of the rock surface provided a controlling guide in this piecemeal reconstruction which involved the making of some 80 new negatives from the original sectioned photographs. The final result was the product of the technical skill and patience of Mr. G. Williams, of the Department of Anatomy, University of Sydney.

The census table indicates the range and frequency of subjects.

There are some unique features—unique, that is, for Mootwingee. Decorated and armed men accompanied by dingoes (sic) predominate and, to a lesser degree, the omnipresent emu with its tracks and eggs. The majority of the men are in ritual or ceremonial attire or posture. There are extremely few similar figures on other sections of the Mootwingee galleries and none comparable to the Cult Hero (sic) with his elaborate head-dress and decorations. It is the only example of a group in which one predominant Hero is associated with other men similarly posed and illustrating a similar theme, but in whom the elaborateness of head-dress and decoration is progressively reduced. It suggests an aggregation of all grades of ritual status from Hero down through lesser Heroes, full initiates and finally novitiates.

There is a suggestion of ornateness about practically all the subjects, which is not found elsewhere at Mootwingee. The position of the rock overlooking a ravine adds to the impression of drama in this composition.

The only two snakes found among the engravings are here.

Apart from the rock of the little women, the woman on this rock (in a different form of depiction) is the only female representation in the engravings.

It is only on this rock that human hands and feet occur.

Two of the men, one metre apart, are linked together by an elaborate and extensive intagliated pattern which George Dutton says is a tree. This is also unique at Mootwingee.

The combination of variety plus high frequency of individual figures is unequalled in the gallery. Track Rock bears many more figures, but they are all tracks.

Representation of dog in Australian rock engravings is uncommon. Here there appear to be 16 in a circumscribed composition.

Plate XX, Fig. 1, looked at as a picture, gives the impression that the Cult Hero in a magnificent head-dress and with two dingoes standing on his sides is presiding (at the top left-hand corner) over the scene. Flanking him to his left side, a series of heavily-armed men have defined but not elaborate headgear and decorated boomerangs and dingoes. Somewhat lower the motif of armed men with dingoes is repeated, but the decorations are absent and the emu motif appears and becomes predominant. At the right lower margin of the rock the decorative element re-appears in the two men linked by the tree design. A huge boomerang and a large coiled snake make a striking centre-piece. The solitary woman in the top right margin seems curiously detached from all this welter of subjects, and so does a solitary dingo below her.

This change of motif across the rock surface is not abrupt ; there is a gradual and subtle intermingling of possibly three or four separate themes, so that it looks like a story in panorama of tribal occupational life. Spiritual and profane activities would seem to be concurrently related.

Style : (See Text Fig. 2.) The barred style is represented by No. 33 (hollow-bodied barred man), No. 34 (barred head of the Cult Hero), No. 44 (man's barred head).

The broad intaglio band style is represented by No. 21 (? weather break). Also in the series of figures Nos. 139-153, which is not regarded as part of the Dingo Rock composition, No. 142 shows two bands within a semi-circle from which extend two projecting bands ; superimposed over one of these is a fully pecked emu track.

Figures outlined by a deeply intagliated groove, with intagliated bands across the body and with partial regional inpecking varying from light to medium, are represented by No. 17 (emu) and No. 22 (cockatoo).

A tiny man (No. 45) is similar in style to Nos. 144-153. This No. 45 gives the impression of " not belonging " to the Dingo Rock composition, but there is no means of saying whether it was engraved before or after the main series.

Two other figures of men, Nos. 47 and 48, while much larger than the tiny men just mentioned, are nevertheless very stick-like in style (see also Pl. XX, No. 3).

All the remaining figures on Dingo Rock are engraved in the fully pecked intaglio style.

The outline in most cases is irregular, in several cases extremely so. It suggests inaccuracy such as might derive from freehand percussion blows. It has given a woolly appearance to some of the dingoes (sic) and will be discussed further on.

Oddities in motif : (See Text Fig. 2). In No. 18, the head of the emu has the shape of an emu track. The legs of this same emu are indicated by a single line and this line is also representing the arm of the man in No. 42.

Incorporated into the tree pattern between Nos. 41 and 42 are three emu tracks which incidentally lend some impression of foliage to the pattern, provided one accepts identification of the pattern as a tree.

In three cases—No. 34 (Hero), No. 36 (heavily armed, smallish, thick-bodied man) and No. 47 (stick man)—the head is pecked in outline only. Also in Nos. 43 and 44 (elongated and somewhat ornate men) pecking is absent within the head and neck outline. In No. 44 it appears to be deliberate, in No. 43 it could be accidental. This " hole in the head " appearance occurs in paintings of stick men in caves at Wuttagoona, north of Cobar (unrecorded). This might indicate affiliation of motif in engraving and painting at these sites.

The more-or-less circular dots have already been shown to represent emu eggs, certainly when they occur in clusters (Plate XXII), with the possibility that other bird or goanna eggs may be represented. Emu eggs may therefore be represented by the isolated dots. While dots are recorded from eastern Australia and the Lower Murray, it is not implied that in those sites the dots also represent emu eggs. It is necessary to remember that Breuil and others have recorded the dot motif painted and engraved in Europe. At Mootwingee, on Dingo Rock, random dots occur in large numbers ; furthermore, while the cluster in No. 19 is obviously an emu clutch, another cluster of smaller dots in No. 21 presents a problem in identification. If the main figure is an emu, the dots obviously represent a clutch of eggs. But our informant, Mr. George Dutton, says the main figure is not an emu, but is the weather-break where the two wives in the Eaglehawk and Crow Myth sheltered. The human footprints are those of the women and of the nephew they were trying to avoid. The cluster of dots, according to Dutton, is a heap of faeces deposited by the women, as in the myth, to hinder the pursuing man. It is to be noted that of the footprints two occur in larger male and four in smaller female size. (The other author, F. D. McC., identified this engraving as a wind-break prior to our discussions with the informant, but thought also that it was sheltering a family and a dog.)

This small composition of figures in No. 21 provides circumstantial evidence for the reliability of Dutton's information that some of the engravings are portrayals of mythology, and for his familiarity with Dingo Rock.

Two items difficult to identify are Nos. 23 and 24. At first sight they look like unfinished engravings of emus. No. 23 could be a misshapen emu, or a boomerang, because there are other boomerangs in the Main Gallery associated with clutches of eggs as is this one. No. 24 could also be an uncompleted emu or a truncated boomerang, but it is only slightly curved and has a cord-like appendage ; an identification as a bull-roarer could be made. No. 23 is not an impossible candidate for similar identification.

Intention of portrayal : Every figure in the Dingo Rock composition is apparently intended to be a realistic or naturalistic representation. Nevertheless the certain identification of a number of figures is by no means easy and in eight cases is impossible.

Anatomy and draughtsmanship : (See Text Fig. 2.) There is an absolute absence of anatomical accuracy. Only two examples approach reasonable truth in proportion and structure. These are an emu apparently trying to pick up an egg with its beak (No. 19), and an emu standing fully erect (No. 20).

In the criterion of anatomical accuracy, most Australian art is bad ; the incised pictographs of Djamar (on Tjuringa 6 and 7 figured by Worms, 1950) are exceptions to this statement. At Mootwingee, apart from the two emus mentioned and the emu tracks, the engraved figures are anatomically exceptionally bad.

The human portrayals on Dingo Rock are grotesqueries of caricature. All appendages are grossly shortened relative to total stature. Fingers and toes are very seldom shown. When they are, they may range from two to six per member. Note the star-shaped arrangement of five toes on the left foot of man No. 52, the three-toed right foot in Nos. 37 and 39 and the two-toed right foot in No. 46. Lateral projections at the sides of the head may represent ears and/or part of a head-dress. Head, neck and body are almost amorphous, elbow and knee joints are not indicated. Penis is portrayed in only five of the 19 males. Man No. 49 appears to have two left legs.

Emu No. 17 is similarly distorted, but here the gross shortness of the legs relative to the body is accentuated by the exaggeration of its three-toed feet. Its head is indicated only by its beak. In contrast, emu No. 19 is given no toes at all. No. 22, arbitrarily identified as crested cockatoo, might be a distorted emu or some other bird.

No other living forms in Australia resemble a human being or an emu, hence these should be unmistakable. Yet the problem frequently arises of differentiating, for example, human from lizard in Aboriginal art. It will be necessary to attempt an anatomical analysis of figures Nos. 1-16, Dingoes (sic). The difficulty of the task is highlighted by the distorted portrayals of what should be such unique and unmistakable forms as emu and human, but analysis is helped by taking into consideration the Mootwingee artists' predilection for (1) grossly shortened limbs ; (2) random portrayal or omission of smaller anatomical items, e.g., ears, penis, fingers, toes ; (3) indifference as to number of digits, if they are portrayed.

The surprising thing is that the subjects can be identified at all when so grossly caricatured. It is still more surprising that, seen in context, these figures take on the guise of reality and immediately convey some meaning or story ; this is particularly the case with the Dingo Rock assemblage.

The apparent paradox can only be explained by the very real skill of Aboriginal draughtsmanship, used here to mean capacity to design and arrange subjects sufficiently skilfully as to create the impression of integration and inter-relationship. As in some examples of modern European art, the overt interpretation may not coincide with the story the artist intended to convey.

Description of Nos. 1-16, *Text Fig.* 2, *Dingoes* (*sic*). (The subjects in their context can be seen in Pls. XX and XXVII.)

Tourists examining the engravings and people, including pastoralists, to whom photographs and pictures of these subjects have been shown have variously identified one or several or all of them as white man's dog, cat, sheep, cattle, horse, pig, fox, rabbit and as koala and dingo. One of us (F. D. McC.) added the hairy-nosed Wombat to the list, and the other (N. W. G. M.) for good measure mentions Thylacinus and Sarcophilus. Our informant, George Dutton, at his first inspection of photographs and tracings, called them dogs. He was not interested in a differentiation between dingo and domestic dog ; he said that in stories (legends) like that of Jaru the hunter the animals were just called dogs, but he supposed they were dingoes in those days.

The approach becomes one of elimination.

The sheep has been most frequently suggested because in some of these subjects (Nos. 1-6) the outline is very woolly, no tail or only a rudimentary tail is shown, ears are not depicted and the legs are short. It has already been pointed out that the outline of some of the men, particularly the Hero, No. 34, the large man, No. 38, and the partly destroyed man, No. 39, is equally woolly and that this woolliness of outline is simply due to imprecise alignment of the pecked pits or gashes, probably due to freehand blows with some implement. Lack of tail and ears is an argument of no force whatever, remembering the lack of fingers, toes, penis, ears, neck, joints in the majority of the engravings of men. Shortness of leg is also an argument without force similarly by analogy with the human figures where the legs are disproportionately short to an absurd degree and also by analogy with the legs of the emu in No. 17. It seems irrational, furthermore, to contemplate Aboriginal stockmen, while armed with boomerangs and ritually decorated, tending the white man's sheep.

The fox has been suggested for figures Nos. 8, 13, 14, apparently because brushy tails are represented in these subjects.

Evidence is almost, if not absolutely, conclusive that the cessation of engraving at Mootwingee preceded the advent of the European probably by several centuries. All the white man's animals are thereby excluded.

Koala has apparently been suggested because subject No. 1 appears to be standing on or clinging to the left side of human No. 31, and subjects Nos. 2 and 3 similarly to the left and right sides of the Hero No. 34. Subjects No. 4 and No. 12, however, while under the left arm in each of humans No. 52 and No. 49, have their backs towards the sides of the human figures. Subjects Nos. 5 and 6 are under the left and right arms respectively of human No. 38, but a little further removed from his body, and demonstrate a perfectly dog-like stance, certainly one which no koala could emulate. Subject No. 7 under the right arm of human No. 39 is standing on a dead wallaby. Ultimately, in subject No. 16, the mammal is entirely alone. In Plate XX, Fig. 1, it can be seen on the right margin of the higher part of the rock a little below the solitary woman. This sequence of motifs has shown the mammal in intimate contact with the ornate Hero, in lesser contact with lesser ornate humans, appreciably separated from undecorated but armed humans, killing a wallaby by its own effort, and finally in complete isolation. There are very few recordings in Aboriginal art of the dingo in association with man, and no others showing this sequence of progressive separation in their relationship.

Subjects Nos. 1-7 are practically identical in size and in morphological outline. What any one of these is, they all are. A dog can jump up the side of a man but a koala cannot stand like a dog, so the koala must be excluded.

The wombat can be eliminated by reference to its range of habitat, its natural habits, its form of depiction in rock engravings elsewhere and its morphological appearance in the engravings at Mootwingee when considered in the context of the prevailing art formula there.

Vombatus hirsutus, Perry, 1810, the Common Wombat, has small, short, rounded ears and naked nose and is the largest of the wombat species, but its habitat is the south-eastern Australian hilly or mountainous country. *Wombulata*, Iredale and Troughton, 1934, the Hairy-nosed Wombat of mid-southern Queensland, has a hairy muzzle but ears which are longer, narrower and more sharply pointed. *Lasiorhinus latifrons*, Owen, 1845, the Southern Hairy-nosed Wombat, also has a hairy muzzle and longer, narrower, pointed ears. Its habitat is south-west New South Wales, Victoria and southern South Australia. I am indebted to Mr. B. J. Marlow, of the Australian Museum, for the further check observation that neither European historical records nor palaeontology extend the habitat of any species of wombat to the plains of north-western New South Wales, beyond or west of the Darling River.

The wombat has a recalcitrant nature, is nocturnal and shows no inclination to fraternise with man. It is essentially a burrowing animal, can run for a short distance, is a very poor climber and cannot jump. This rules out the three examples of the mammal climbing up or jumping up or clinging to the sides of two men.

Campbell (1899, Pl. XI, 1) illustrated a 10-ft. long outline engraving near French's Forest, Sydney, which he identified as wombat ; he acknowledged R. H. Matthew's prior and similar identification in 1895. Morphologically, it is absolutely different from the Mootwingee figures, having a very pointed snout, exceedingly short legs for its total bulk, well-defined small ears and, particularly, a dorsal convexity extending in a uniform sweep from tip of snout to rump. This convex curve is pronounced in the cervico-dorsal junction and clearly intends a different anatomical portrayal from the intention at Mootwingee, where the cervico-dorsal outline is not convex in any figure and is markedly concave in some.

While the Aboriginal artist has poor capacity for presenting anatomical accuracy, he has rich capacity as a caricaturist for seizing on a salient feature for exaggeration. In depicting the wombat, he has elected for caricature essentially the bow-like dorsal outline sweeping continuously from snout tip to rump, although the relative shortness of leg, smallness of ear and rudimentary tail may receive acknowledgment also.

The total subjects at Mootwingee—human, bird, animal and reptile—are depicted statically. In this formula the limbs are excessively shortened relative to body length. In dynamic portrayal, as in some cave paintings in Arnhem Land, the formula to produce an effect of fluid movement is based on the introduction of curvature which gives the sense of action and is particularly effective when combined with exaggerated length of limbs relative to stature.

It is true that all species of wombats have rudimentary tails, and legs which are excessively short relative to total body size. The legs of the animals engraved on Dingo Rock, when analysed within the static art formula of Mootwingee, are far too long to permit classification as wombat. The absence of ears and tail in some of the engraved animals was explained when eliminating identification as sheep, and applies similarly for wombat. It can be noted also that animals Nos. 6, 10 and 12 have five legs and a tail, unless one of the legs is meant to represent a penis.

Sarcophilus, a much smaller animal with a longish tail, has a savage disposition in the wild state but is tameable in captivity (Troughton, 1957, 47). Its skeletal remains have been recorded from Lower Murray excavations (Hale and Tindale, 1930 and Mulvaney, 1960) in Layers VI, VIII and IX Devon Downs and Layer 7 Fromm's Landing apparently at approximately the 3000-4500 B.P. mark. Identification as *Sarcophilus* would help to date the engravings, but morphologically it has to be excluded.

Thylacinus has smaller ears than the dingo and a tapering, dependent, non-brush tail. Given that the engravings were sufficiently ancient, *Thylacinus* would be more difficult to exclude than the wombat on morphological grounds, excepting that while its stance and its head and forequarters are dog-like, its hindquarters and tail are kangaroo-like. It is more shy and furtive than either dingo or wombat and apparently untameable, at least in adult life (Troughton, 1957, 50-2).

Neither *Sarcophilus* nor *Thylacinus* have been recorded in Australian art, and both probably became extinct on the mainland too early to permit their portrayal in the latest engraving phase of full intaglio. It is difficult also to visualise an harmonious gathering of 11 Thylacines, or for that matter wombats either, under the arms of nine men.

All such identifications are esoteric, Sinbadian and unnecessary when the engravings look like a credible and orthodox association of man and dog. In the writer's opinion, all possible candidates outside the dingo are adequately excluded.

It is necessary to mention that subjects Nos. 14 and 8, situated respectively under the left arms of men Nos. 43 and 44, have very ragged outlines, and the possibility that they may portray weapons or other objects dependent from waist belts, and so may not be animals at all, has to be faced. Massola (1960, p. 91, 92) makes reference to the importance of the ritual belt for carrying weapons or ceremonial objects. Mountford (1956, Fig. 44 G) shows a hollow-bodied man and says, " There is no explanation for the projections from the hips ". Incidentally, Mountford's 1956 Figs. 16A, 25, 18B show the motif of smaller figures postured under the outstretched arms of larger humans, and his Fig. 41 shows a profile silhouette of a small man or animal clinging to or standing on the left side of a human, as in examples on Dingo Rock. Mountford makes no comment about it. Subjects Nos. 43 and 44 are less decorative than the Hero (No. 34), but are still somewhat ornate, and the similarity of motif favours an identification of animal for the subjects under their arms rather than pendant ritual objects. Hornex rubber impressions were taken from the entirety of the Dingo Rock motifs in 1959 with the intention of making casts for display in the Australian Museum. This has not yet been done, but, when completed, minute study of such casts may permit a revised assessment of subjects Nos. 8 and 14.

Subjects Nos. 13 and 15 are also somewhat doubtful. No. 15 looks like a dog sitting up in a begging posture, but it might possibly be meant to represent some sort of bird. No. 13 suggests an animal sniffing at the right foot of man No. 51. Mountford, 1956, Fig. 32C, shows an animal of similar shape and in identical posture sniffing the right foot of a huge woman. In that same picture another animal near the woman's right hand has almost identical posture and morphological outline as animal No. 4 on Dingo Rock. Mountford simply says " a woman and two unidentified animals ".

We are left with 13 subjects which can be classified with considerable certainty as dingoes, two which may be some sort of ritual weapon or decoration and one which may be a bird.

Affiliation : Recordings of rock " engravings " of dingoes from other sites are so scanty that it is premature to attempt an analysis of comparative portrayal or affiliation. McCarthy, 1959, Plate 22 and Fig. 4, I, No. 6, shows a dingo drawn in black outline but with a rubbed interior believed to have been made with an abrading stone. This is on the wall of a cave at Conjola, coastal New South Wales. Whether this can legitimately be used in comparison of engraved motifs is debatable. Perhaps it should be reserved for comparison in drawings and paintings. From the Hawkesbury District, coastal New South Wales, McCarthy (1956, Fig. 3, Nos. 9, 10 and Fig. 5, No. 65) recorded three dingoes which are engraved in the outline style. Campbell (1899, Pls. VI and XI) recorded two dingoes in outline at French's Forest and Manly Cove, Sydney. From the full intaglio technique at Depuch Island, McCarthy, 1961, shows Fig. 94, a dingo which was recorded also by Stokes, 1846, and by Petri and Schulz, 1951, and Fig. 321 which McCarthy also identifies as possibly dingo. The three subjects at Hawkesbury are morphologically akin with one another. Campbell's two are similar to one another. Otherwise no morphological similarity of portrayal exists between the various recordings mentioned nor are any akin with the Mootwingee portrayals. In paintings, the morphological treatment of the dingo differs radically from all of these engravings and I am grateful to Father E. A. Worms for drawing my attention to some of the paintings.

Weapons : The census table and Text Fig. 2 provide adequate information except to note that subjects Nos. 33 and 51 hold in their left hands objects which may be unhafted hand axes, and one is tempted to think these could be related to the making of the engravings. The left hand was favoured for weapon holding in the case of portrayal of sky god, ancestor, or hero performing some feat (Elkin, 1949, McCarthy, 1959, 1961). The apparent object in the present figures may merely be a crude portrayal of the hand itself and the observation is not stressed. Note also the decorative effect of objects (? ritual) tied to the boomerangs of two men in particular, Nos. 51, 52.

Unidentified objects : Nos. 25-29 are amorphous intaglios.

Emu tracks : Nos. 56-59 show accessory projections from the median toe, varying from 2-4 in number. No. 58 is particularly striking, and at first glance looks like a small four-legged animal with a large horned head. These examples indicate that the Aboriginal artist drew from observation of tracks left on the ground, not from the shape of the actual emu foot itself.

Forward thrust of the emu's central toe on a wet mud or clay surface produces a splashing impression identical with these engravings. Compare also Nos. 69, 70 and 72. No. 69 shows a separate heel pad impression, Nos. 70 and 72 are much larger, but whereas No. 72 has a very posteriorly prolonged but united heel impression, No. 70 does not show heel impression at all.

The total variety in Nos. 56-103 can be seen in tracks left by emus, and the variation in shape of track depends on the condition of the ground surface when the emu walked on it, plus, of course, the effect of varying momentum at different speeds and torsion effects if the emu was not keeping to a straight line. The unique occurrence of human tracks has been described. In opposite contrast with the other engraved rocks at Mootwingee, wallaby or kangaroo tracks are very few in number on Dingo Rock.

The tree pattern complex (*Text Fig.* 2, *between Nos.* 41, 42 ; *see also lower portion of Pl. XX, No.* 1) : No. 42 shows a human figure with two mammillary projections from the sides of the body. A well-defined penis is present, so presumably the figure is male and the lateral projections apparently represent some objects slung in a waist belt. The head is four-pronged, but two of these prongs may represent ears. One of the vertical prongs terminates in a knob, the other links up with a curvi-linear pattern. In his left hand is a spear thrower ; his right arm is coincident with the leg of an emu and beneath this dual-purpose (human arm, emu leg) line are two emu chicks. Continuing from the man's arm (or emu's leg) is a wavy line extending up to the emu's neck which carries an emu track also serving a dual purpose in representing the emu's head and beak.

Our informant, Mr. George Dutton, said the man was the nephew and the wavy line the net with which he caught the emus. On the other side of the nephew is a series of different-sized human foot tracks made by the nephew, his uncle and the uncle's two wives. There is also (No. 122) a large well-carved hand, and (No. 121) a cruder smaller hand ; no explanation is given for these. The uncle was addicted to emu meat and tree grubs, like witchetty grubs. He compelled the nephew to catch emus (note in Pl. XX, Fig. 1 the many emu tracks nearby), but refused to let the nephew eat any of the emu meat. The nephew also had no woman and coveted the uncle's wives. The nephew thought of a plan. He told the uncle he'd found a tree with wonderful grubs in it, but that, if he showed it to him, the uncle would have to chop out the grubs. The uncle climbed the tree and began to chop the bark. The nephew blew on the tree and invoked it to grow, which it did. The uncle said, " Here is the sky ". The nephew said, " Catch hold of it," and then invoked the tree to shrink again, leaving the uncle in the sky.

The curvilinear pattern between Nos. 41 and 42 is the tree connecting nephew, No. 42, on the ground and uncle, No. 41, at the top of the tree. Within the lines of the tree pattern is a goanna (see Pl. XX), but its significance is not known. In the uncle's right hand are a boomerang and an axe (?). The axe (?) is shown as an oval blob within and beyond the concavity of the boomerang. The uncle's left arm appears to be double, embracing an oval area within which is a more or less spherical shape and a crescent of seven dots. There is no information about these, but it is very tempting to think they might indicate the moon and the seven sisters. In actual fact, however, the informant said the seven sisters were not at Mootwingee at all, but were at Sturt Meadows.

Appreciably further up the rock surface, situated about midway between the huge boomerang and the solitary woman, is the weather break, No. 21, already described. Here the two wives took refuge and called for their husband. The nephew said, " There's your husband up in the sky, the man in the moon ; you'll be my wives tonight ". They temporised with him, defecated outside the break and ran away. In pursuit he ran into the faeces and gave up the chase.

Head-dresses : The Hero No. 34 has a head represented only in outline, surmounted by a symmetrical semi-circular band within which are three vertical bars. Above this a parallel, double-curved band is fused with a disc on the Hero's right and perhaps originally with another on his left. Fissures in the rock surface have destroyed parts of the engraving. There are two long vertical projections at the summit of the head-dress. The head-dress measures 25 x 25 cms. The Hero with his head-dress, prior to destruction of the lower half of the figure, was probably 55 cms. tall and so the largest subject on the rock. In the Hero's right hand is an irregular patterned disc and in his left hand a decorated, but rather small, curved figure fusing with the disc above it. Perhaps it originally resembled a boomerang. (Our informant said they were ceremonial bundles of leaves.) Standing on his left and right sides are, respectively, the two dingoes, Nos. 2 and 3. This engraving has the most weathered appearance and is probably the oldest figure on the rock.

Fig. No. 43 has a series of eight vertical lines ascending from his head and five from the boomerang in his left hand. Fig. 44 has three vertical lines ascending from a single barred outline head-dress or head. Fig. 52 has one long and two short spikes rising from a bulbous head-dress. The remaining male figures show a progressive simplification in portrayal of the head outline.

Relative age of the engravings on Dingo Rock : Subjective observation of the condition of the pecking, together with objective observation of the degree of shattering of the engraved figures, indicates that some engravings on Dingo Rock are older than others.

The oldest stratum quite clearly includes the elaborate Cult Hero, the decorated " Sub-Heroes ", the initiates or novitiates armed with boomerangs, and the dingoes ; of similar age appearance are the figures illustrating the huge boomerang, the coiled snake and the grotesque emu which is partially intagliated, banded and heavily grooved in outline. The solitary woman approximates more closely to this complex of figures also.

The more southern and south-eastern sections of the rock surface carry engravings of more recent appearance, and most of these are involved in Dutton's story of the man in the moon from the Eaglehawk and Crow Myth.

The best-preserved pecking occurs in the two small emus, which are also the best-designed figures from the viewpoint of anatomical accuracy.

The figures shown in Plate XX, No. 3, look more recent than the earliest stratum on Dingo Rock and the morphological style is also similar. It is possible that they represent somewhat ater recapitulation of the earliest complex of motifs on Dingo Rock.

MYTHOLOGY OF MOOTWINGEE, ACCORDING TO GEORGE DUTTON

Our informant was Mr. George Dutton, a half-caste Aboriginal. He was interviewed by both writers in 1959 and has now been interviewed by one of us (N. W. G. M.) three times. His age is perhaps 70 to 75 years.

His life story has been described by Beckett (Oceania 95-103, 1958). Repetition here need go no further than to say his mother was a full-blood Wongumara and his father a white stockman who had been in mateship relation with the full-blood Maliangaba husband of the mother. His Aboriginal stepfather became instructor and provider, requested him to submit to initiation and did all he could to transmit the " dark people's " knowledge.

Dutton is sophisticated at the European level, and has considerable contempt for the efficacy of such practices as " boning ". (Beckett, p. 99, has more fully referred to Dutton's lack of interest in " the superstitious side of Aboriginal belief " and, instead, his concern with " the big ceremonies ".)

Nevertheless, it has been his lifelong inclination, and, it might almost be said, obsession, to acquire the " dark people's " knowledge.

Our first talk with him in 1959 was cut short when he became obviously ill, and one of us (N. W. G. M.) persuaded him to enter hospital in Wilcannia. He then accepted remuneration, but at no time had it been mentioned previously. He appears to have a mission to get his stories recorded. He demanded that Beckett's paper be read to him meticulously, sometimes asking for a re-reading of a few lines. It is a tribute to Beckett that only one line was challenged by Dutton.

As Constable Salisbury observed, there can be no doubt that Dutton believes in and mentally lives this mythology, while at the same time avowing himself a Catholic, having equated in part the Aboriginal mythology with the Christian religion.

Apparently Dutton had not previously been interrogated about mythology relative to the engraving and painting galleries, in brief with a view to archaeological interpretation. In the past other recorders questioned him about kinship, marriage rules and ceremonial procedures including initiation and his mind was geared to talk at these levels.

It was difficult, therefore, to alert him to what amounted to a new theme in questioning. His conversation persistently drifted off to Euriowie and south-west Queensland and stories of mythical snake *muras* wandering across country and naming places.

Dutton, having recovered from his 1959 pneumonia, was subsequently hospitalised in Bourke, and on the occasion of my last interview, July, 1961, he was again complaining of bronchitis. It has therefore not been possible to take him on to the actual engraving sites at Mootwingee.

Beckett says Dutton was born on Yancannia 50 miles north of White Cliffs, but Dutton is now insisting that Mootwingee and Wilcannia were his early home, some of his very early years having been spent near the site of the old hotel at Mootwingee (see map). (Beckett says that from the age of seven, Dutton travelled with his step-father . . . . " up into Queensland, over as far as South Australia and down to the Darling at Wilcannia ". It was on these trips he learned the names of the hills and waterholes and the myths and legends associated with them, p. 97.)

At our first interview his information was generalised, embracing the total terrain of Mootwingee, Sturt Meadows, Euriowie. At the last interview his information had become appreciably more particularised.

His description of the topography of the Mootwingee galleries, caves, creeks and waterholes and of the Sturt Meadows outcrops is accurate, although he had not been there for several years.

He gives a fair account of the topographical location of a few of the engravings at Mootwingee, but a much more detailed localisation of the Euriowie engravings which Dutton spoke of as paintings. He categorically says that, with the exception of rain-making, no ceremonies occurred at Mootwingee in his lifetime, or in his stepfather's, and, he doubts very much, in his stepfather's father's lifetime, either (which means in the last 100 years, and so prior to white occupancy in 1866). He knew of one rain-making ceremony at Mootwingee when he was a very small boy, but he attended others conducted at Euriowie. He can give a minute and detailed account of this.

He gave his description in what he called Bagundji or River talk, construing and translating as he went along. His interest in rain-making apparently stemmed from the fact that it involved preparations, setting out with a body of men, arriving at the site, making more preparations, conducting the ceremony, waiting under rigid conditions for results and then " all pulling out " to return home. It involved " doing " rather than " believing ".

As will be seen relative to the Cult Hero (sic) on Dingo Rock, he is overprone to jump to a diagnosis of Rain-maker. However, as had already been described briefly (Plate XXI, Fig. 1), he is quite firm in insisting that this rock shows not a hunting, but a rain-making, party ; he knew the rock was there and says he remembers it.

He correctly described the location of what we have arbitrarily called Track Rock and interpreted it (Pl. XXI, Fig. 5, already described) as a portrayal from the Eaglehawk and Crow Myth of the incident where *wagu* the crow tricked *biljara* the eaglehawk. This story goes on to tell of the eaglehawk's brother-in-law, the spider, taking his dogs to find all the eaglehawk's feathers and patch him up again. He says the spider and his dogs are among the pictures ; we could not find a spider among the engravings, but there are several dogs. Dutton says the dog engravings which we located are not the spider's dogs, and they are not the hunter Jaru's dogs either, because Jaru didn't take his dogs with him, thinking he could hunt better alone, and so lost the kangaroo and was then abused by his wife Kukali.

Our " Rock of the Tall Hats " he cannot place topographically and says he doesn't remember seeing it, but from the photographs he identified the head-dress as Kungulada (previously described Pl. XXI, Fig. 2) or, in his own language, Karikumari. The orientation of his memories towards Nockatunga, in south-west Queensland, may be intruding here.

The story of the kangaroo escaping from Jaru, he says, is painted (sic, engraved) at Big Cave (see map), but much better at Euriowie. This was pointed out to him and explained by his step-father from the paintings. In July, 1961, using a stick to draw in the sand, he recalled the figures of the hunter and his dogs and their tracks and the red and the grey kangaroo at Euriowie, but he said the paintings at Big Cave were not much good, the kangaroo wasn't there at all.

He has never seen paintings made nor had his step-father, but they knew what they meant.

He himself asked about the rock which we have arbitrarily called Dingo Rock. He described its position, but referred to it as the rock with the tree—the tree which took the uncle up to the Moon when the nephew was trying to get the uncle's wives.

Beckett, p. 95, says, " Although Dutton sometimes drew a long bow, he proved essentially a realistic and perceptive man ". Dutton's proneness to Rain-makers, his possible rationalisation of " Big Cave " paintings as compared with his absolute certainty about the Euriowie engravings, makes one suspicious of the " long bow ". But the engravings of the men with dogs on Dingo Rock produced no evidence of this. He flatly said they were " fellows with their dogs and he didn't know any story about them ". The solitary woman, No. 40, on Dingo Rock, however, he says is Kukali (the wife of the hunter, Jaru) ; " she should be on the rocks, there she is ". When asked why the men with dogs couldn't represent her husband, he said, " No, that's not them. But that big roo should be on a rock by himself somewhere ". (Note what we have called " Roo Rock," see map.) He also says he doesn't know any stories (myths) about dingoes. The elaborately decorated figure No. 34, however, produced a response. In 1959 it was a Rain-maker ; in 1961 it was Kulabiru. Challenged about this, he said, " Well, he's a big shot because he's got all that head-dress and ' leaves ' in his hands ". In brief, he doesn't know. But subsequently, of his own accord, he said, " That fellow might be Kulabiru, his picture's up there somewhere ; he went up that creek, he didn't go up near the cave ".

Then followed the story of the journey of the *mura* Kulabiru from away down south, up over the ridge a little east of the site of the Old Cobb Hotel, across the flats and up Giles Creek and on to White Cliffs (see map, Text Fig. 1). Other journeys of Kulabiru included camping with the Seven Sisters at Sturt Meadows before they went up to the skies.

Later again he said, " That Kulabiru went through Gnalta ; he sat down there to have a spell ; he saw a neat round hill and said that's my head cap and called it that. After he left White Cliffs he came straight across to the River and saw a dog pad and said I'll stop here. That picture on the rock, he's got a big round hat and those fellows had dogs. He might be Kulabiru because he's there somewhere."

All this is tenuous, and obviously he was trying to piece together sections of knowledge to arrive at a conclusion sufficiently convincing for his own acceptance rather than mine.

Setting aside these deductions, the real fact in Dutton's knowledge is that the *mura* Kulabiru made the waterholes in Giles' Creek and that his picture is somewhere on the Gallery. That much had been transmitted to Dutton by his stepfather.

Asked why the sites had fallen into disuse, he said simply that the people had gone, they were not so many, they became fewer, there weren't enough for gatherings and they moved away. In other words, Mootwingee was entering the realms of Aboriginal prehistory even before European intrusion.

It is easy, therefore, to appreciate that the engravings soon lost their individual meanings and interpretations, while the main narrative of the mythology of the region was handed on within the body of traditional knowledge. It is possible that we will never know whether the engravings were made to portray, for example, the journeys of the *mura* Kulabiru and the episodes from the Eaglehawk and Crow myth, or whether this traditional mythology was at a later period rationalised as being the interpretation of the engravings.

Dutton has absolutely no knowledge of how the engravings were made, nor had his stepfather nor his father in turn. He thinks it could have been *before* the dark people, and said no one could make them in this hard rock and if the dark people did make them, perhaps it was in mud before it got hard like rock.

His information strongly supports the opinion, derived from hypothetical calculations in the description of Dingo Rock, that engravings ceased at Mootwingee long before the white man's arrival.

It can be accepted that any long bows drawn by Dutton are no more than rationalisations or elaborations on the base of some factual knowledge. If he doesn't know he says so. An attempt was made to probe him about other sites near Cobar. He most forcefully expressed himself as knowing nothing about anything east of Wilcannia. His stories lie west or north.

Summary of Dingo Rock and of Dutton's Information

Morphological and other analyses classify a minimum of 11 and a maximum of 16 animals as dingoes.

Dutton's information strongly supports the hypothetical opinion, calculated in the description of Dingo Rock and its motifs, that engraving ceased at Mootwingee prior to European arrival.

Knowledge of how the engravings were made was lost certainly prior to 100 years ago and probably much longer, but meaning for some of the intagliated groups has been transmitted up to the present time. Briefly the engravings are portrayals of myths. The myths are remembered in detail, but capacity to locate and to recognise and construe the engraved figures portraying them falls into four categories :—

1. Several groups representing incidents from the Eaglehawk and Crow Myth are familiar to the degree of detailed interpretation. Portrayal of other incidents is known to exist, but there is uncertainty about their location. On Dingo Rock, the Man in the Moon story from the Eaglehawk and Crow Myth is very completely identified and the engravings thereof occupy the south-eastern third of its surface.

2. Lesser incidents, like the legend of the hunter Jaru, are located and identified in some sites (Euriowie), but only vaguely referred to in others (Mootwingee). Thus, on Dingo Rock, Kukali the wife of Jaru, and perhaps a few kangaroo tracks are less forcefully identified than the components of category 1.

3. Representation of the *mura* Kulabiru and perhaps of his activities is known to exist, but his topographical location among the engravings has been forgotten. The largest and most elaborate humanoid figure on Dingo Rock was tentatively suggested as being Kulabiru by the informant, but progressively rationalisation made the identification stronger. Critically analysed, two facts support the rationalisation. Firstly, the *mura* was known to be depicted " somewhere " in Main Gallery. Secondly, the Cult Hero engraved on Dingo Rock is absolutely unique for the Mootwingee Galleries.

4. Other naturalistic figures are identified at their overt value, but any knowledge of why they are there or what myth they portray is denied. On Dingo Rock, the sequence of motifs of men with dogs is identified as such and no more.

The question arises as to whether the engravings were originally made to portray the myths or whether they were later rationalised as expressing the myths. The former possibility is supported by what would appear to be a stratification in the categories of identification ; particularly as the categories of vaguest identification contain the engravings which appear to be the oldest on Dingo Rock, and, incidentally, the most ornate, although crude in morphological portrayal.

Apparently represented in the oldest stratum of engravings on Dingo Rock is the *mura* ancestor or " spirit being " concept, with its ancillary myths of creating and naming natural features, of the travels of Heroes with their dogs and of the transmission of their accomplishments to initiates and novitiates.

The humanoid figures elaborately accoutred and ceremonially posed suggest the site was one for re-enactment of the myths, combined probably with initiation ceremonies. The fact that the deeply grooved, banded and partially pecked emu, the huge boomerang, the coiled snake and the solitary woman appear to belong also to this older series of figures suggests that totemism and increase rites may also have been involved.

The Cult Hero here identified was perhaps not seen, certainly not described nor illustrated, by earlier writers. Hence Elkin (1949, 153) was led to state : " There is, however, no indication of cult heroes " (at Mootwingee). Had Elkin been in possession of present data, he would, doubtless, have stressed more vigorously his remarks (op. cit., 141, 148, 155) about *mura* mythology and its influence in this region.

The possibility that this complex of figures may additionally represent tenuous derivations from the concepts of the rainbow serpent and of the left-handed sky-hero cannot be entirely excluded.

The other complex of figures on Dingo Rock, equated by Dutton with the Eaglehawk-Crow myth, suggests that this theme had more recent fixation in Aboriginal activities and memory than the *mura* traditions.

ENGRAVING STYLES AT MOOTWINGEE

The styles present in the site as a whole are limited in number.

The linear series (Text Fig. 5) is of the simplest kind and lacks the complexity seen at sites in north-western Australia in particular. The little stickmen lack the grace and variety of those depicted in northern Australia. The barred style is seen in one sacred board or shield (Text Fig. 7), in 12 human figures and in six head-dresses (Rock of Tall Hats, Pl. XXI, No. 2). The broad pecked band style is represented in circles and ovals, and in some of the designs (Text Fig. 6). Partial or regional intaglio is seen in a few figures with heavily pecked outline and bars—kangaroo (Pl. XXII, No. 3), emu (Text Fig. 2, Nos. 17, 22).

The full intaglio is the dominant style, and is well exemplified in the various humans animals and their tracks.

Pecking Methods

Previous authors have stated that the pecking at Mootwingee was done with a harder stone, such as stone axe (Pulleine, 1926, 180), flint or some such material (Riddell, 1928, 15), or with a sharp-pointed stone implement, driven by a wooden or stone hammer (Black, 1943, 13, and Mitchell in same reference, 68). No doubt the term flint was used loosely, since flint does not occur in the Mootwingee area. Basedow (1914, 198) said the implement used at South Australian sites was perhaps a stone chisel of similar type to that employed by the central Australian Aborigines in modern times. Elkin (1949, 139) was told by a Wilyakali man that the carvings at Euriowie were made with a narrow hand-chisel by the Seven Sisters who went up into the sky to live. Care should be exercised here in interpreting what is meant by a narrow hand-chisel. Several generations of natives have passed on since white settlement began in the 1860's at Mootwingee and earlier on the southern side of the Darling River, so that metal tools, among the first items given or traded to natives in Australia in the early days, were known to them in the far west about a century ago.

A narrow hand-chisel could mean a metal chisel in the mind of a modern native several generations removed from the use of stone tools. On the other hand, narrow ground-edge stone chisels found in the west are up to 6 in. long (McCarthy, Bramell and Noone, 1946, Figs. 294-5). The smaller ones were hafted in gum and would, like the axes, probably break out of the haft after a few blows on rock, but the longer ones could be used as hand tools. None of these chisels are recorded from Mootwingee, Sturt's Meadows or Euriowie, and we did not find any in our intensive collecting. As they are rare implements, they might well be rejected for pecking purposes. One would expect a stone tool used for engraving to be a common strong type when the immense number of pecked figures is considered.

The pittings are of two main kinds. The majority are gashes or cuts, oval to tear-drop in shape, which vary in size from $\frac{1}{8}$ to $\frac{3}{8}$ in. long, and up to 3/16 in. wide. Their size is related to that of the figure, being smaller on the average in small figures and bigger in such figures as the three large kangaroos, emu and bandicoot. The other kind is a circular pit, seen commonly in the emus' eggs, and appears to be used most frequently on the smaller figures, and for comparatively delicate work. It is obvious that implements of different types and sizes were used for the gashes and pits, unless there was one that would make both kinds of markings.

The gashes and pits could not have been done with a ground-edge axe unless the corner of the blade was sharp or pointed, and maintained in such a shape. In general the axes from western New South Wales have rounded corners and blades. The hafted adze or chisel of the *tula* type, which Basedow suggested as being the pecking implement, occurs at Mootwingee where we collected the prepared adze and its two kinds of worn-out slugs (McCarthy, Bramell and Noone, 1946, Figs. 105-08). This implement occurs in the largest numbers, and its working edge is suitable for gashing but not for pitting. It is doubtful, also, whether the gum haft would stand up to more than a few blows on rock before the adze flake would fall out, a constant irritation to an artist. The pitting requires a very hard, sharp, cornered or pointed implement, and the gashing a sharp edged tool, both more efficient when used in the hand, and what it was or they were we do not know. We found no implement in all our collecting that would be entirely suitable and common enough for the task of either Sturt's Meadows or Mootwingee. The natives apparently did not leave the implements on the site, otherwise worn and broken ones should be found there in comparatively large numbers. The puzzling point about this problem is that a well-prepared stone tool appears to be required for pecking work, and yet the archaeologist is as yet completely baffled in his attempt to identify or find such an implement at or beside any of the rock engraving sites in Australia. In its absence perhaps an irregular pointed lump of stone served the purpose, and was thrown away when of no further use. The rounded and flattened faces of hammerstones are completely unsuitable for fine pecking.

The process of pecking begins in one of two ways. In a simple figure like a little man, boomerang, tracks and the like, scattered gashes or cuts were made all over the surface (Pl. XXV) to be pecked. Several layers of the pecking were necessary to produce the thickly-pitted or battered appearance of a deep intaglio, and these layers were either done on separate occasions or one after the other in the one working session. In figures like the emu (Pl. XX) on Dingo Rock, and the other large figures, the outline was usually, but not always, defined with a groove, and the body pecked in afterwards. The large kangaroo (Pl. XXIII, No. 3) illustrates this method well, and suggests that the more intensive pitting was done in zones on big figures. The intaglio surface of the figures, generally from $\frac{1}{16}$ to $\frac{1}{8}$ in. deep, although some are $\frac{3}{16}$ and $\frac{1}{4}$ in., in depth, have apparently been pecked over intermittently in preparation for ceremonies year after year, or generation after generation, and in the whole gallery only a few boomerangs, emu and kangaroo tracks are as much as $\frac{1}{4}$ in. deep. Occasionally an existing figure in outline has been altered to a full intaglio, a process which seems to have been taking place with the big kangaroo (Pl. XXIII, No. 3), with an outline body and heavily pecked tail.

The general impression one gets at this site is that the pits were made with free hand blows with a sharp pointed or cornered implement. The outline of the figures is uneven and the gashes are out of alignment, suggesting a freehand percussion rather than the firmer outline that could be made with the better controlled hammer-gad method.

The engravings in the rock shelters are very crude on the whole, being made in a softer and coarser rock unhardened by exposure to the sun.

Here and there, on the vertical walls of the valleys, are to be seen figures of little barred men battered or bruised out in a thin ferruginous layer. This simple process produces a fresh buff-coloured silhouette or intaglio which stands out against the dark brown to black colour on the wall. This bruising technique will be discussed in the section on Affinities. In these wall figures, however, areas of distinct pittings, identical with those in the main gallery figures, are to be seen, and they probably belong to the full intaglio period.

Patination and Antiquity

Pulleine (1926, 180) stated that some of the petroglyphs at Mootwingee are apparently of great antiquity, being almost invisible, and rocks near the water were covered with old and new carvings. He considered that none of them are very recent and that, as a whole, they were made when the rock slope was in better condition than now. Barrett (1929, 416) wrote that " our experts pronounced them to be age-old, 5000 to 10,000 years perhaps. Others are evidently more recent, done not more than a century ago . . . it seems certain that Mootwingee was a camping ground of some tribe that roamed the western country before the coming of the blacks that explorers found in occupation . . . the bird footprints by the pool are the oldest of the carvings ". Mitchell (in Black, 1943, 69) said that the now fast crumbling and cracking would indicate no great antiquity as the breakdown of exposed rocks in arid areas is comparatively rapid. He pointed out that one has to be careful is ascribing any great antiquity to these petroglyphs in the absence of geological evidence. Riddell (1928, 15) said that the newer were mixed with the old, and many appear to be of great antiquity. Dow (1938, 109) said these pictures gave one the impression of great antiquity, for what were once continuous designs have now been broken up by the cracking and exfoliation of the surface.

Observations in the future on the deterioration of these rocks will form a guide to the antiquity of the engravings on them. Factual data at present is scanty, and it is understandable that the subjective opinions of these writers should be conflicting.

A more detailed attempt at analysis appears to indicate that the majority of the engravings in the Main Gallery were pecked into fresh rock surfaces exposed by the shedding-away of a previously higher layer of rock.

These comparatively hard fresh surfaces are resistant to erosion for a long time, duration as yet unknown, as demonstrated by the larger proportion of the engraved figures in Main Gallery. Even if it be assumed that the full intaglios were engraved up to the time of white occupation, and the custom may have ceased long prior to that, it is obvious that the surfaces of the rock are practically unaffected by weather erosion. Instead, the effect of the natural elements and time is to produce cracking which progresses and leaves portions of a carving displayed on both sides of a fissure. Accentuation of the process has resulted in great slabs of engraved rocks, bearing portions of figures around their edges, becoming separated from the main layered mass and from each other on the steep slope of the gallery.* Other blocks from a higher layer have fallen into the wide crevices between the slabs, and as there are occasional carvings on their now uppermost side, it is clear that some occupied their present position before the Aborigines abandoned the site. Those in the crevices beside Dingo Rock apparently occupied such position after its engravings were completed.

The majority of the engraved figures are not patinated nor weather-eroded to any degree. The photographs (Pls. XX-XXVII) show that the pecking is extraordinarily well preserved and, further, that the process of cracking and breaking up of the rock is more rapid than the weathering of the actual figures. It is quite clear that the carvings were not made on cracked surfaces. The central problem of their antiquity therefore rests in the rate of cracking of the rock rather than in the rate of weathering of the engravings, and this rate is unknown.

Relative to this rate, a little evidence is available from assessment of minor discrepancies in the condition of the Main Gallery as shown in photographs taken between 1920 and 1930 and those taken between 1955 and 1959. Thus in Riddell's plate (1928, Pl. i) a large emu track is shown on the edge of a fissure, but the section of stone bearing it has now either broken away or it may have been taken by a visitor. Vandalism may nullify such approach, but certainly based on available photographs the cracks across many figures appear to have got no wider in 30 years. Hence, the rate of expansion of these cracks appears to be very slow, and this is supported also by the fact that some engraved rocks show no signs of cracking at all in a minimum time of a century since the white man occupied the country. The slabs, of course, may be slipping imperceptibly all the time, and only intermittently move appreciably apart.

It must also be noted that in some engravings the sandstone has weathered away to leave exposed the edges and faces of the conglomerate it covers, and this is almost the final stage in the destruction of the actual engraving by weathering agencies. This form of weathering has attacked a number of full intaglio tracks and a little man. (Pl. XXII, No. 7.)

* In the main gallery a large area of rock in the middle of the slope has broken up and either disintegrated or gone down the slope into the creek bed. This has removed the support of the carved face higher up the slope, with the result that it has cracked into a dozen or so separate slabs, now up to 3 or more feet apart, which are also slipping down the slope. A concrete wall should be built across the middle of this slope to arrest this process and hold the carved slabs in position, otherwise the gallery will disintegrate completely in time.

Another process that takes place is that engravings on rocks in the creek bed, or where water flows or seeps over them for some time after rain, become smoothed and faint and covered with a clear glossy patina (Pl. XXI, No. 3). The deposition of silica in this way hardens the rock surface, but the water at the same time wears it and the engravings down very gradually. Good examples are a lizard beside the large pool at the base of the slope below Big Cave, human hands and other figures on a boulder just below this pool in the bed of the creek, and some of the figures on the Rock of the Little Women. The heavily engraved surface (Pl. XXI, No. 5) has also been affected in this manner as it is at the base of the main gallery in a position where water from excessive rains would cause the creek to rise high enough to wash along its face. This water patination would be a fairly rapid process in terms of years even though the rainfall in this region is erratic and in the vicinity of only 10 inches per annum.

The main gallery is, in our opinion, the most recent one at Mootwingee. There appears to be an older one, where unpatinated and recent figures are mingled with old and almost weathered-out engravings on a second slope behind the main gallery. A similar range of recent and old figures exists in two smaller places about one quarter of a mile to the south-east of the main gallery. Another very old gallery existed on the steep slope of rock extending from the creek to Big Cave (map), where some very weathered figures still exist on knobs of rock which have resisted weathering agencies.

To sum up, in our opinion, the sequence at Mootwingee is that (1) the engravings were first made on smooth, hard, either recently or freshly exposed rock surfaces which (2) have since been sub-divided by cracks, and (3) fissures caused by the slabs slipping down the slope. Thus, the rocks bearing the nesting emu, banded circles and other figures would be the last engraved at the site as a whole because of the uncracked condition of the surface upon which the engravings are done. Hence it is clear that the age of the engravings varies from the unpatinated ones on uncracked rock surfaces to those which have almost weathered out on hard, resistant rocks, and those on badly cracked blocks which have been displaced in the course of time.

Previous investigators of pecked sites in South Australia, including Basedow (1914), Hale and Tindale (1925), and Mountford (1929, 1935) all reported that local natives, some of them still living tribalised life, who were questioned in the vicinity of various groups of engravings, said they knew nothing about them and usually regarded them as belonging to the Dreamtime. Harney (1952) obtained interpretations of some small groups on Mt. Wedge Station, central Australia, and Elkin (1949) of sites in south-eastern Australia. Hale and Tindale (1925) thought the carvings of circular series of straight indentations, such as might be made with the end of a cold chisel, were probably recent sporadic attempts of living natives to copy the ancestral work without knowledge of its original significance. Mountford (1955) thought a modern hammering technique that he recorded in the Northern Territory to be of similar nature.

Summarised, it can be said that Aborigines living in the vicinity of pecked engravings in various parts of the interior of Australia have denied all knowledge of their making and attributed their creation to the Dreamtime people.

Local natives have never been taken to Mootwingee and questioned on the site about the rock art there.

George Dutton informed us that at no time during his lifetime nor, as far as he knew, during his stepfather's lifetime, was any carving or painting done at Mootwingee, and he has no knowledge at all of how the engravings were made, but some of the mythology relating to the site is still preserved.

The two stories that he gave us agree basically with the Eaglehawk and Crow myth recorded by Tindale (1939) for the Maraura tribe on the lower Darling River, and whose widespread distribution in Australia he mapped. Dutton's story of the moon is act III, and of the crow act II, of the Maraura myth. The important episodes described in both versions include (1) failure of one man to possess two wives of the wrong marriage class, (2) leaving food secretly for them, (3) attempting to kill their guardian by burying him in a grave from which he escapes, (4) killing of the guardian's son, (5) evading of the man by the women leaving large faeces in his way.

But George Dutton was completely baffled by all the designs, and motifs illustrated in photographs shown to him.

The Main Gallery itself has had a long history, extending from an intermediate to a late intaglio phase of engraving, and quite obviously some adjacent engraving sites and particularly the gallery near Big Cave are still older.

CAVE PAINTINGS

The map indicates three areas at Mootwingee where rock shelters were examined. The first and second areas are approximately 3 to 3¾ miles north of Mootwingee Homestead.

The first, shelters 1-4, is in a north-easterly location near the source of Big Cave Creek. Shelters 1-3 extend 250 ft. along the northern side of a high ridge and have uneven rocky floors with no occupational deposit. Two trimmed flakes were picked up in the vicinity, but it cannot now be ascertained what other implements may have been collected here since the discovery of the paintings. Shelter 4 is on the eastern face of an outcrop separated from shelters 1-3 by a broad rocky slope descending steeply from the plateau above to some rock waterholes a furlong to the south-west, representing the beginning of Big Cave Creek. This slope is the site of a gallery of very old and now indecipherable engravings.

The second area, shelters 5-14, three-quarters of a mile south-west of the first series and three-quarters of a mile due south of the Main Engraving Gallery, is located along a ridge forming the south-western and southern boundary of Nootambulla Creek Flats. A broad apron or ledge fronts these shelters, which face due north, and although they are ideal for habitation, occupational deposits were found only in two, Nos. 9 and 14 ; these were excavated.

The third area, shelters 15-21, is distributed over a high rocky ridge 2¾ miles south-south-east of the homestead. A creek running approximately from north to south divides the ridge into a western and an eastern portion. The eastern side of the western portion presents a high steep rock face in which the majority of the shelters occur, all of them offering a wide view of the creek valley, facing some 5° to 10° north of due east. One shelter, No. 20, occurs on the eastern portion of the ridge and faces a little west of north. There are also two shelters high on the almost vertical western face of this eastern portion in which paintings occur ; these were seen through a telescope and were not examined further. There are probably others in equally inaccessible parts of the outcrop. Only two shelters have occupational deposits, Nos. 15 and 16, which were excavated. Scattered implements, including mill-stones, were found on the valley floor.

A total of 21 shelters containing paintings were located and are here described ; six of these also contain engravings.

First Area—Cave 1 : The most eastward of this group is a high shelter, 50 ft. long. A frieze extends for 25 ft. across the back wall at a height of about 5 ft. and presents 30 mostly red, but a few yellow, human hand stencils and red stencils of a boomerang and a coolamon. At the base of the wall a frieze of engravings extends for 16 ft. Most are fresh and unpatinated, but some are old, faded and dirty like the grey rock face. They portray in punctured outlines, half an inch wide and 3/16 deep, tracks mostly of kangaroo, but a few of emu.

The series has been added to, suggesting that successive generations have added tracks as part of a ritual.

Cave 2, *or Big Cave* (*Text Fig.* 9) : This immense shelter is the largest at Mootwingee. The vast sloping back wall presents a ritual setting for the most extensive frieze of paintings stretching for 70 ft. longitudinally, with figures scattered from near floor-level to a height of 9 ft.

There are approximately 137 mostly red and dark red, but some yellow, human hand stencils. They vary from excellent to old, faded, barely decipherable condition. Stencilled also in red are two human feet, a conical object, a club with thick rounded head, two coolamons, a boomerang and a line of four foot-like objects ; in white are a conical object, a pair of conical objects on a bent shaft, six boomerangs, a lizard and a crescentic object ; in yellow are a coolamon, a mammal skin and a stick. Some of these stencils are unique.

A feature of the paintings is the portrayal, in sets of tracks, of several kangaroo hunts. One of these hunts displays 22 tracks of the hunter, interspersed among 100 hind and six fore feet kangaroo tracks in crudely applied, thick white paint ; it begins in the middle of the frieze, leads to a dense concentration of tracks suggesting the animal stopped either to drink or feed, continues eastward along the wall beyond a point where the hunter's tracks cease. This suggests the kangaroo escaped, and is probably the representation of the story of the kangaroo escaping from the stupid hunter explained to us by our informant, Mr. George Dutton, who said this story was portrayed also at Euriowie, but in the latter site portrayal was of the actual hunter and kangaroo instead of merely by tracks.

Separate and similar hunting stories are probably indicated by 20 pairs of kangaroo tracks in red together with a circle of hunter's tracks near a lizard at the eastern end of the frieze, and again by a vertical line of four pairs of wallaby tracks in yellow in the middle of the frieze. Near the western end of the frieze also is a series of 12 pairs of small red tracks, probably wallaby, with six short angled lines beside them.

Other items scattered through the frieze are—In dark red silhouette : two vertical curved lines, apparently part of an old figure, four snakes, lizard. In red silhouette : boomerang. In white silhouette : a set of four boomerangs, three lizards, emu's shank and foot, a set of three vertical rods, shell-backed lizard, apron, plant-like figure. In white outline : lizard. In yellow silhouette : pole club, line of five blobs, snake, short vertical bars.

These paintings vary in age and state of preservation, some of the dark red ones in particular being old and faded. Many of the stencils have been chalked in for photographic contrast by tourists, some from Broken Hill, whose names and addresses have been scratched among the paintings as well as being chiselled into the rock galleries.

Cave 3 : This is a westward continuation round a knobby outcrop of Cave 2. It contains 33 red stencilled hands in varying states of preservation and a faded, dark-red snake winding for 30 ft. up and down along the rock face. Some tourist has outlined this snake in white, presumably for photographic purposes. The snake is not stencilled as stated by Pulleine (p. 187).

Superimpositions in Caves 1-3 : Faded dark-red indeterminate figure under stencils ; red stencils under purplish-red stencils ; yellow stencil under red and white stencils ; pasty white tracks of kangaroo hunt under stencils ; red stencils under white apron ; red and purple red stencils under red snake ; yellow stencilled boomerang under red stencilled hands ; set of three vertical solid white rods under a solid white track under a yellow stencilled stick ; solid white tracks under red stencil paint splashes.

Cave 4 : Long axis lying north-south, 40 ft. long, facing due east, contains a double boomerang-like design in red stencil, 11½ in. long, and a set of intaglios engraved very crudely in the soft coarse rock of the shelter, but identical in subject with those of the outside galleries. They include two men, a man standing on one leg, emu and kangaroo tracks, a vertical line of four emu tracks leading to a clutch of eggs, boomerangs and other indeterminate figures.

Second Area—Cave 5 : Fifteen feet long, six deep and eight high ; contains 10 red and one white stencils of hands.

Cave 6 : Twenty feet long, eight deep, 10 high ; contains 12 red stencilled hands, yellow stencilled coolamon 17 x 7 inches, and thick, yellow, rough-edged smudges over six of the red hands.

Cave 7 : Forty feet long, 15 deep and high ; contains stencils of 12 red hands, three purplish-red hands, one of which is a child's, purplish-red club 20 in. long, superimposed over a red hand, and a yellow foot.

Cave 8 : Forty feet long, 15 deep and high ; the rough back wall is only partly decorated and presents a white stencilled hand, three ovals in thick white outline (one resembling a shield or coolamon 41 x 13 in.), old white emu tracks and indeterminate figures and a red emu track. There are also two pecked emu tracks. Two equally large and suitable shelters adjoining this one contain no paintings or engravings.

Cave 9 : Thirty feet long, contains a pair of red emu tracks, three faded red stencilled hands and a floor deposit which was excavated.

Cave 10 : Fifty feet long, 12 deep, 15 high ; contains stencils of 20 red hands, seven white hands, a white boomerang 18 in. long, two yellow hands and a boomerang 26½ in. long. Superimposition is yellow and white over red.

Cave 11 : Sixty feet long, 20 deep, 25 high ; contains red stencils of 80 hands and two boomerangs 24 and 25 in. long ; purplish-red of 21 hands and boomerang 24 in. long ; white of one hand and boomerang 18 in. long ; yellow of four hands. The red stencilled hands include a closed fist, and a hand complete with forearm. There is also in thick white outline, a small oval at the end of a line, superimposed over the purplish-red stencils. Other superimpositions are yellow over faded red stencils, white stencil over red splashed surface. The bottom ledge of the wall bears indistinct, weathered engravings.

Cave 12 : Fifteen feet long, six deep, 15 high ; contains very faded red stencils of 10 hands and a boomerang 24 in. long.

Cave 13 : Sixty feet long, 12 deep, 20 high ; contains stencils in purplish-red of eight hands and a boomerang 9 in. long ; in 24 hands, two conical objects 11 and 14 in. long, one of which is like a cylcon, a club head 4 x 2 in., a trapezoid 5½ x 2 in.; in yellow a hand on reddened rock and a boomerang 13 in. long. Thick white paste is daubed in three vertical bands. Superimpositions include white boomerang over red hand stencils, purplish-red over red hand stencils. The bottom ledge of the wall bears a lightly pecked circle 7 in. in diameter, a smaller circle and several dozen pairs of kangaroo tracks very weathered and almost indeterminate.

Cave 14 : Thirty feet long, 12 deep, 18 high ; contains red stencils old and very faded of 50 hands, white stencils of 12 hands of which one is complete with forearm, a straight club and a boomerang each 18 in. long. On the lower ledge of the wall are older and more recent engravings of kangaroo and emu tracks ; the more recent show also radiate-circular designs and a little man. Tourists' names are scratched among the engravings. There is a floor deposit which was excavated.

Third Area—Cave 15 : One hundred and six feet long, 30 deep and high, this shelter is 250 ft. above the valley floor and its back wall slopes forward in a series of alcoves and rough faces. A smooth narrow face a few feet above the floor bears stencils from end to end for 30 ft. In one series in the middle of the cave are stencilled 50 hands in red, 41 in purplish-red grading almost to black in fresh examples, 20 to 30 in faded red, two in yellow and one in yellow superimposed on a reddened surface. There are also stencils in red of three boomerangs, two snakes and a club, and in yellow of three boomerangs. Seven hand impressions in wet mud or brown ochre constitute a unique set at Mootwingee.

At the north-western end are six oval shields or coolamons measuring 20 x 6 to 25 x 7 in., all painted in solid purplish-red, five vertically, one horizontally ; 11 vertical white lines are 1 to 3 in. apart and a set of yellow lines form a vertical indefinite pattern ; there is also a dark rusty-red faded lizard.

The dark red ranges from purplish to blackish and the same colours are used both for stencils and other paintings. The floor deposit was excavated.

Cave 16 : Twenty-five feet long, 10 deep and high, on a slightly lower ledge than Cave 15 this concave walled alcove has a painting frieze from waist to standing height above a line of pecked engravings on a sloping ledge one foot above the floor.

There are stencils in dark red of 20 hands, in bright red of 50 hands, a pair and two more boomerangs, two coolamons and a baby's foot ; in white are 18 hands, a club 10 in. long with bulbous head, three coolamons and apparently a model of a mammal cut out of bark ; in yellow are 17 hands of which 12 are over a reddened surface. The coolamons measure 13 x 8, 12 x 4, 23 x 9 in. Silhouettes in a thick, crudely applied, pink-white paste in the middle of the cave include a shallow curved boomerang, three vertical bars 4 to 6 in. long and a horizontal bar.

An old series of dark red emu tracks occur among the stencils and above the frieze on a separate ledge.

Superimpositions include white coolamons over red boomerang stencils, white over dark red and bright red hands, yellow over white hands, pink-white silhouettes over red emu tracks and human foot and hand stencils. As the white stencils are freshest in appearance, the underlying red stencils give a false impression that the white hand stencils are infilled with red.

The engravings extend for 15 ft. and the intaglio grooves range up to 1 in. wide and $\frac{1}{8}$ in. to $\frac{3}{16}$ in. deep ; they include emu and kangaroo tracks, boomerangs, an elaborate curvi-linear design, double crescent, bladed club, a mammal-like figure and two little men. One of these has an indeterminate triangular object, perhaps a boomerang, in his left hand and a mammal-like figure under his right arm. The other man has lateral projections from his head, a boomerang in his right hand and an indeterminate subject a little like a mammal under his left arm. These two men are very similar in composition to the men with dogs described on Dingo Rock in the main gallery of engravings.

The floor deposit was excavated.

Cave 17 : Consisting of two alcoves, the first is 8 ft. long, 5 ft. deep and high, containing seven red and three yellow hand stencils in faded to medium condition. The second, 12 ft. long, 6 deep and high, contains in the northern corner nine red stencilled hands varying from faded to well preserved ; in the southern part are five very faded white and five faded yellow hand stencils.

Superimposition : Large dark red kangaroo tracks underlie all other figures ; six yellow lines overlie indeterminate red figures, little red men are over thick and crude white goanna, yellow emu track over faded red stencilled hand, thick pink-buff figures over dark red tracks and light orange tracks. The wide range of colours is notable.

Cave 18 : Also consisting of two alcoves, the first is 30 ft. long, 10 deep and high, has a frieze 10 ft. long and 4 ft. high in which are stencilled 13 red, seven white, three yellow hands, a yellow and a faded red snake, and there is a bright red circular object, 4 in. in diameter. There are rows of three, four and five single emu tracks, a pair of kangaroo tracks and a semi-circular line, 8 in. long all in dark red ; eight parallel sloping lines, 10 to 13 x $\frac{3}{4}$ to 1 in., in red ; three bars, 6 x $\frac{3}{4}$ in., and an angled outline design 20 in. across in white ; an angled line, a set of three boomerangs, emu track and oval in yellow.

ANALYSIS OF SUBJECTS, STYLES AND COLOURS

Subjects	Colours	Stencils	Sub-totals	Impressions	Silhouettes and linear	Sub-totals	Outlines
Human hands	Red ..	807	..	..	..	..	..
	White ..	52	..	..	..	..	..
	Yellow ..	76	935	..	..	..	..
	Brown ..	..	..	7	..	..	..
Human feet	Red ..	3	..	..	..	..	..
	White ..	1	..	..	29	29	..
	Yellow ..	1	5	..	..	..	..
Bandicoot	Red ..	..	..	..	1	..	..
	White ..	1	1	..	1	2	..
Mammal skin	Yellow ..	1	1	..	..	..	..
Snake	Red ..	3	..	..	4	..	..
	Yellow ..	1	4	..	1	5	..
Lizards	Red ..	2	..	..	2	..	..
	White ..	3	5	..	3	5	1
Boomerangs	Red ..	15	..	..	..	..	..
	White ..	9	..	..	2	..	..
	Yellow ..	2	26	..	3	5	..
Clubs	Red ..	6	..	..	..	..	..
	White ..	3	..	..	..	..	..
	Yellow ..	2	11	..	1	1	..
Coolamons	Red ..	5	..	..	..	..	..
	White ..	3	..	..	..	..	..
	Yellow ..	5	13	..	..	..	..
Ovals	Red ..	2	2	..	1	..	..
	White ..	..	..	..	..	..	3
	Yellow ..	..	..	..	1	2	..
Shields	Red ..	..	..	..	6	6	..
Men	Red ..	..	..	..	2	2	..
Tracks	Red ..	4	4	..	..	..	..
Kangaroo Tracks— Hindfoot	Red ..	..	..	..	35	..	..
	White ..	..	..	..	100	..	..
	Yellow ..	..	..	..	8	143	..
Forefoot	Red ..	..	..	..	9	..	..
	White ..	..	..	..	6	15	..

Emu Tracks	Red ..	1	1	..	25	..	..
	White ..	..	..	..	3	..	..
	Yellow ..	..	..	..	1	..	..
	Orange ..	..	..	..	3	32	..
Plant	Red ..	..	..	..	1	..	..
	White ..	..	..	..	1	2	..
Emu leg and foot	White ..	..	..	..	1	1	..
Double boomerang design	Red ..	..	..	..	1	1	..
Apron	White ..	..	..	..	1	1	..
Conical	Red ..	2	2	..	2	2	..
Trapezoid	Red ..	1	1	..	..	..	..
Rectangular	Red ..	1	1	..	..	..	..
Circular	Red ..	1	1	..	..	..	..
Angular	Red ..	..	..	..	..	..	1
	Yellow ..	..	..	..	1	1	..
Semi-circular or arc	White ..	2	2	..	4	4	..
Anvil	Red ..	..	..	..	1	1	..
	White ..	1	1	..	..	..	..
Pronged	White ..	1	1	..	..	..	..
Bifurcated	Yellow ..	..	..	..	1	1	..
Blobs	Yellow ..	..	..	..	8	8	..
Indeterminate figures	Red ..	..	..	..	4	4	..
	White ..	..	..	..	4	4	..
	Yellow ..	..	..	..	3	3	..
	Dark red ..	..	..	..	6	6	..
	Pinkish-buff	..	..	..	3	3	..
Bars or rods	White ..	..	..	..	35	..	..
	Yellow ..	3	3	..	15	50	..
		..	1,020	7	..	339	5

Superimposition : Purplish-red under all others, red stencilled hands over dark red emu tracks, yellow stencilled hand over red bars, white over yellow and yellow over white hand stencils, white bars over yellow hand stencils.

The second alcove, 12 ft. long, 8 deep, 15 high, contains faded stencils of hands, 18 red, four white, of which one is on a red surface, and one yellow.

Cave 19 : Subdivided into four alcoves, this shelter is some 60 yards further north-westward along the ridge and lower down the ridge face with a steeply sloping rocky floor. The first alcove has 13 red and three yellow stencilled hands, the second has 10 red and four yellow stencilled hands, white stencils of a human foot, an anvil-shaped and a semi-circular object ; the third has red stencils of 12 hands and an amputated emu's foot, yellow stencils of 15 hands and a boomerang ; the fourth has red stencils of a boomerang and a hand which is very faded and five red vertical parallel bars 7 in. long.

Cave 20 : Forty feet long, 15 deep, 20 high, contains stencils of 40 hands in faded red, 24 in dark purplish-red varying from faded to fresh, a pair of 4-in.-long ovals in red ; in the middle of the shelter is a group of hands stencilled in fresh and perfectly preserved white, one of which includes the forearm. Adjacent is another in which index and middle finger are extended and the other digits closed, and finally a unique example of a hand in profile with fingers extended and thumb closed across palm. The white hands are superimposed over the reds. The rock has spalled away in the top eastern area, taking many stencils with it.

Cave 21 : Ten feet long, six deep and high, this very concave alcove is a quarter-mile or so north-westward along the western portion of the ridge, separated by a series of rocky ledges from a rock waterhole 40 ft. below in the valley floor.

There are two pairs of emu tracks in red, a purplish red stencil of a child's hand under a bright red stencilled hand, two yellow over red hand stencils, trial splatter patches in red and a sequence of dark purplish-red over red over yellow over bright red stencilled hands.

Tabular analysis reveals an extremely limited number of styles among the paintings ; only six occur at Mootwingee out of a total of 31 known in Australia (McCarthy, 1958, 33-4). Stencils far outnumber all other styles ; monochrome silhouettes and linear figures are next in frequency ; outlines are rare. The few silhouettes of animals compare unfavourably with those in neighbouring areas, especially in the Darling River-Cobar-Bourke area figured by Black (1943) ; there are no unusual or complex figures in the linear series.

A wider range of subjects occurs among the stencils than has been recorded in any other one locality in Australia. Their styles and the limitation of the colours to monochromes are archaic elements in Australian cave art.

Analysis of Colours

Colour	Stencils	Others
Red	853	101
White	76	194
Yellow	91	43
Orange	..	3
Brown	..	7
Pinkish-buff	..	3
	1,020	351

Red, which includes a range from faded to dark and purplish shades, is the predominant colour used at Mootwingee, as it is on Groote and Chasm Islands (McCarthy, 1955). In the Sydney-Hawkesbury district of eastern New South Wales there are 911 white, 300 red, 17 yellow and four black human hands and only eight feet recorded among the 1,330 stencils in 170 rock shelters, as against 200 other subjects in dry black pigment, 173 in red, 76 in white and none in yellow (McCarthy, 1958, 36, 39). Thus, although stencils predominate numerically in both eastern and western New South Wales, red was preferred in the west and white in the east. Black was not used at all in the west, yellow only for a very small number of stencils in the west and still less in the east. In two caves in south-west Arnhem Land (Macintosh, 1951, 1952) only 22 stencils (hands) occur among 94 figures ; of the stencils 20 are red, only two are white. There are also 25 red silhouettes on some of which are superimposed white silhouettes. The more recent figures are bi-chromes. A count was not made of stencils on Groote and Chasm Islands, but red is by far the commonest in these islands and in the north and interior generally. These differences in the uses of colours in techniques and regions may have important cultural implications in view of the existence of distinctive eastern and inland archaeological cultures (McCarthy, 1958, 185).

SUPERIMPOSITIONS

The superimpositions do not indicate any distinct periods of styles and colours at Mootwingee. The main points are : (1) a few dark red silhouettes appear to be among the earliest paintings ; (2) yellow was used concurrently with, but more rarely than, red ; (3) the thick pasty-white kangaroo hunt in cave 2 is painted over and under red and yellow stencils and does not belong to the latest phase of painting in Big Cave, nor similarly with the same theme in cave 16 ; (4) the red stencils are consistently under the white ones, and white stencils become more common in the final phase of painting at Mootwingee ; (5) silhouettes and stencils are concurrent.

AFFINITIES OF PAINTINGS AND ENGRAVINGS

Beckett (1958, 91) ascertained that the religion of the north-western or Corner tribes of New South Wales was closely related to that of the Lakes Tribes investigated by Elkin (1931, 53, 58, 60). Elkin said that the main features in the religion of the Lakes tribes were : (1) the possession, at least by all the northern tribes of the group, of a patrilineal totemism of the *talu* or increase type, in nearly all cases combined with a matrilineal totemism with which the members' sisters' sons were associated ; (2) sex totemism and dream totemism ; (3) a type of mythology in which the heroes are called Mura-mura, whose exploits took them from south-western Queensland to Eyre's Peninsular ; (4) the *wiljaru* rite, the highest stage of initiation, the outward sign of which is a pattern of cicatrisation, consisting of two vertical rows of short parallel scars. It is notable that 23 out of 24 matrilineal social totems supplied by a Yantruwunta informant are edible, although the totemites did not eat of this totem. They ate freely of their patrilineal increase totem. The sex totem of the women is a small bush with milky sap, that of the men a small bush with a white flower ; they are referred to as mate or uncle and are play totems. Beckett (1958, 91) recorded that hair depilation and tooth avulsion (optional), circumcision in the *milia* ritual, and the high *wiljaru* took place in the initiation ceremonies of the Corner tribes. Such is the background of ritual and belief of the tribes in whose territory the Mootwingee engravings are situated.

An important criterion in determining the age of these pecked intaglios in Australia will be to establish and date accurately the archaeological horizon, which is a phase of the axe-making period, to which the pecking technique belongs. Pecking is an early Neolithic technique which probably diffused into Australia several thousand years ago. Distribution suggests original introduction in Cape York or Arnhem Land ; speading over the greater part of the continent, its use in full rock engraving lagged behind that for fashioning stone implements. The Aborigines shaped axes, cylcons, percussion and grindstones, ceremonial stones, *Yodda* and *Ooyurka* tanged implements, picks, *tjuringa* (McCarthy, Bramell and Noone, 1946) by pecking throughout the huge region extending from north-western Australia through the Northern Territory and central Australia to Queensland, New South Wales and Victoria. It was only in a major part of Western Australia that the technique was not employed. Its use in rock engravings extended only as far south-east as western New South Wales and the Flinders Range in South Australia, but the Queensland limit is uncertain.

It is as yet premature to make a detailed comparative study of the chronology and distribution in Australia of the techniques and motifs among the pecked engravings. Mootwingee is the first extensive pecked intaglio site at which the recording of every motif has been attempted. Hall, McGowan and Guleksen (1951) provided a useful comparative study of the Pimba site, in South Australia, as did Worms (1954) for the Abydos and Wamerana sites in north-western Australia. Extensive sites like Yunta Springs, Salt Creek and others in the Flinders Ranges in South Australia, Sturt's Meadows and Koonawarra in western New South Wales, and others in central, western and northern Australia have not been studied in sufficient detail to provide adequate comparative data.

Worms (1954) concluded that a recent stratum of pecked engravings, which he called Gurangara petroglyphs, emanating from the desert tribes, overlaid an earlier outline stratum in the upper Yule River galleries. McCarthy, in 1958, established three phases of rock engravings at Port Hedland and on Depuch Island (McCarthy, 1961) which he has called the Outline, Linear Design and Pecked Intaglio phases. His discovery that the full intaglio pecking is the latest technique in rock engraving in this general region suggests that all of the pecked stone artifacts belong to the same late period in Australia's prehistory.

The following discussion is an attempt to explore the relationships and chronology of techniques, subjects and styles among the pecked engravings of South Australia and western New South Wales to ascertain whether the same sequences exist in this region and in north-western Australia.

Despite the wide distribution and large number of sites of rock paintings and engravings in Australia, very little attention has been paid to the problem of distinguishing the prehistoric figures and groups from the historic or those still functioning in the living culture of Aboriginal tribes. McCarthy (1955, 1958, 1959) has drawn attention to this problem, and working from superimpositions of figures, has denoted certain chronologies among the paintings on Groote and Chasm Islands, at Oenpelli in western Arnhem Land, and in eastern New South Wales.

Hale and Tindale (1930, 208-11) reported three series of engravings at Devon Downs on the lower Murray River in South Australia. The earliest series, which Tindale (1957, Fig. 1) allied with their Mudukian or earlier Pirrian periods (with a radiocarbon mid-period dating of 4250± 180 B.P. years from the present time, consists of straight abraded grooves in both haphazard and radiate sets. These grooves are widely distributed in rock engraving sites of the interior of Australia generally, and form, apparently, the earliest series in existence. None were found at Mootwingee, but a small number exist at Sturt's Meadows and also at Port Hedland. The second series, belonging to the late Mudukian and early Murundian periods, consists of abraded or incised outlines of tortoises, fringed circles or "sun" designs, tailed and barred circles, bird tracks, very large U-shaped figures, wavy lines, and scores of pits or holes.

Basedow (1914, Pls. IIB, IVB, VB, VIB, VIIB, IXB, XA-B, XIII, XIVA) illustrated, but did not comment upon, an important series of superimpositions in two sites at Deception Creek in the Flinders Ranges. His photographs demonstrate that at these sites fully pecked intaglios of owls, human feet, lizards and other animals, tailed radiate figure and emu tracks, are engraved over circles with a thin punctured outline. The consistent superimposition of the full intaglios over the circles indicates that the latter preceded the former in the Flinders Range area. A number of these circles, together with outline tortoises and no intaglios, occur at Burra at the southern end of the Flinders Ranges, and form a good example of the Outline phase of engravings. Furthermore, in many of the Flinders Range sites plain circles are associated with a range of simple motifs which include linear emu and kangaroo tracks, single barred and linked circles, arcs, branching figures and others, which appear to form the earliest group of motifs among the interior engravings generally. They may be linked with the second series at Devon Downs and with the Burra series. Basedow's Pl. XIIA, at Yunta Springs, is a good example of this group of motifs, and he refers (op. cit., 198) to circles, wavy lines and emu tracks at a site in the Mann Ranges.

Another correlation is suggested. The motifs incised on the cylcons include various combinations of straight parallel lines in sets, which resemble the straight abraded grooves at various rock engraving sites mentioned above. On the cylcons there are also bird and kangaroo tracks, simple pittings or holes, cross, encircling rings, winding or spiral groove around the stone, radiate figure, barred circle, arc, oval, and an M-like figure (McCarthy, Bramell and Noone, 1946, 67). These motifs are characteristic of the abraded groove and linear design phases of engraving, indicating that the cylcon continued in use from the abraded groove to the linear design phases in Australia. Those fashioned by pecking and polishing, however, were made by techniques which obviously belong to a later period than the pre-axe Mudukian of Devon Downs, indicating that the stones continued in use into a comparatively recent period, e.g., they bear archaic designs from early phases of rock art, but those fashioned by pecking and polishing in later phases bear no pecked intaglio figures or designs.

The more complex line motifs, such as concentric full and half circles, spirals, snakes, apron, plume, grid, clusters, wheel, maze and line patterns, belong to an intermediate phase of rock engraving. We have noted at Sturt's Meadows the following series of superimpositions of full intaglios over linear designs (See Plate XXVI) :—

Full intaglio lizard over line design.

Full intaglio emu and kangaroo tracks, beside a sphere, over line design of radiate type.

Full intaglio human foot over linear man or lizard.

Full intaglio lizard over line design centred on small hole in rock.

Full intaglio emu and kangaroo tracks over linear designs (four examples).

Full intaglio emu and kangaroo tracks over cluster designs (four examples).

Full intaglio emu tracks over complex line design.

Full intaglio kangaroo track over spiral.

Full intaglio kangaroo track thin outline circle.

Basedow illustrated (1914, Pl. XB) a full intaglio emu track over a wheel design at Deception Creek east, and we found a full intaglio conical figure (probably a kangaroo track) over a thin outline circle at Mootwingee. These superimpositions clearly indicate that the full intaglios are later than this group of line motifs ; many of the latter, complex in nature, form a group which may be considered a linear design or intermediate phase of engraving in the interior and north-west

of Australia. Very few of the motifs of this phase occur at Mootwingee, the concentric circle only once, but they are abundant at Sturt's Meadows. It is important to note, however, that the concentric circle and U, sets of sinuous parallel lines, radiate circle, grid, and other motifs of this phase of engraving are richly developed in the cave paintings, body decoration, ground drawings and portable ritual and secular art of central Australian tribes.

Hall, McGowan and Guleksen illustrated (1951, Pl. XXVII A) a full intaglio emu track over a branched design near Pimba. They refer (op. cit. 377) to the design as the " leaf fern " type of Mountford (1935), but make no comment about the superimposition.

At Mootwingee emu and kangaroo tracks are to be seen on practically every engraved rock surface. While the majority are natural size, some are smaller, but others are much bigger, those of the emu being up to 11 in. long and of the kangaroo up to 9 in. long.

One kind of emu track with the heel pad and the three toes clearly separated in the carving of it (Text. Fig. 4, No. 1, and Text. Fig. 2, Nos. 65, 69) is represented by a number of examples from small to large in size. It is the type recorded by Hall, McGowan and Guleksen (1951, 376) near Pimba, South Australia, and which, they suggested (op. cit. 379), indicated Aboriginal knowledge of footprints of a creature now extinct, and which, Tindale (1951, 381) suggested in a separate paper, opened up the distinct possibility that Australian man may have been contemporary with the extinct giant bird Genyornis. Tindale (1957, 40) again referred to these as probable tracks of giant birds, possibly from the Tartangan period.

As this track is in the full intaglio style which is the latest phase of pecked rock engraving in Australia, and identical examples can be seen where living emus have walked across claypans and sand, it is considered to be merely a variant of emu track. The emu track is a simple one to reproduce, but the heel pad is usually omitted in the engravings. Both the heel pad and one toe are commonly omitted in the hind foot track of the kangaroo, and very few of the forepaw tracks are shown among engravings. It is significant that the very large and full intaglio tracks of the kangaroo, with separated heel pad, long middle toe and one lateral toe, have never been doubted as representing the living species of euro or kangaroo, and no one has claimed, as with the emu tracks above, that they belong to an extinct species.

An important superimposition is that of a full intaglio radiate figure, with a tail, over broad intaglio banded circles, at both Deception Creek and Yunta Springs (Basedow, 1914, Pls. VIIB, XIVB). There is as yet insufficient evidence at hand to decide whether the broad intaglio bands preceded or are contemporary with the full intaglios, and it will be necessary to study long series of superimpositions to decide this point. Another important superimposition at Sturt's Meadows is that of full intaglio kangaroo tracks over triple circle (with thin lines) and over the body of a goanna. The body of the goanna bears widely scattered pits and this style of engraving may also belong to the intermediate phase. There are also superimpositions of full intaglios over one another at various sites.

From the evidence of superimpositions presented above, we are led to the conclusion that the full intaglios, which form the great majority of the engravings at Mootwingee, belong to the latest phase of engraving. Strictly speaking, the banded and full intaglios are the only strictly pecked engravings, the others being better described as having a conjoined punctured outline. Basedow (1914, 198) considered the full intaglios to be a more advanced type than the tracks and circles. It is possible that some of the complex line motifs were carried from the intermediate into the later full intaglio phase. The full intaglios portray human beings and their tracks, and various animals—kangaroo, emu, bandicoot, lizards, snakes, owl and others—and their tracks and eggs. We cannot as yet account for the emphasis upon naturalistic subjects in this phase, well exemplified at Euriowie, where emu and kangaroo hunts, snakes, lizards and men predominate in the full intaglio technique. It explains the comparative rarity of full intaglios in South Australia (McCarthy, 1958, 22) where the process of diffusion of these motifs was apparently in progress at the time of white occupation. A feature of the late intaglio phase of engraving is the portrayal of human feet, which are recorded at many sites in the Flinders Ranges, and in great numbers at Port Hedland (McCarthy, manuscript).

The little men hunting and fighting at Mootwingee are practically unknown in the Flinders Range sites. What appears to be a stickman carrying a boomerang or spear-thrower occurs at Panaramittee (Mountford, 1929, 343, Fig. 124), although he does not distinguish it as such. In no other pecked engraving site in western New South Wales are they so numerous as at Mootwingee. They are armed with up to three boomerangs in each hand, some carry spear and spear-thrower. McCarthy (1960, Figs. 63-70, 314) recorded them in 1958 on Depuch Island, north-western Australia, and further recording will probably reveal them in other localities. At Mootwingee they could well be regarded as spirits of the rocks, concerned mainly with the hunting of emus and kangaroos, bandicoots and lizards, collecting the vine berry or fruit, performing the various totemic increase, initiation and historical ceremonies featured at the site in times gone by, and living the same mode of life as the Aborigines, in a similar way to the Mimi

spirits of the rocks at Oenpelli in western Arnhem Land. The Bagundji tribe on the mid-Darling River had a belief in dangerous spirits called *mullas*, formerly a tribe which lived north of the Bagundji. They were pygmies with arms that reached to the ground, and on the men's elbows was a sharp hatchet-shaped bone which was thrust backwards when fighting. They were finally surrounded by the Bagundji and exterminated, and during this time they made the *kopi* caps to cool their burning heads. They now live in hollow rocks and small caves in the Macpherson Ranges, from where they wander at night in search of Bagundji natives travelling alone (Newland, 1888, 12-3). It may be pointed out that little men armed in hunting, fighting and dancing postures and scenes are commonly depicted in the rock shelter paintings south of thé Darling River, in a triangle formed between Wilcannia, Cobar and Bourke, and also in the cave paintings of the Adelaide Hills. It is not yet known whether these little armed men form a separate phase not yet defined, or whether they have diffused widely as a part of the intermediate phase (because they are linear), or as part of the late pecked intaglio phase.

While the pecked intaglios of people and animals at Mootwingee are reasonably good examples of the pecking technique, they are not of a very high artistic standard. The lizards are simple linear stylisations, or broad lumpy figures. The emus, kangaroos and bandicoots are stiff in posture and lack anatomical details. The emphasis, however, at Mootwingee upon the motifs of emu eggs and chicks, and to a lesser degree upon the hunting of this great bird, and of the kangaroo, denote these animals, together with the bandicoot and the few other animals engraved, to be important totems of the area. The vine bearing a fruit or berry also comes within this category. Thus, although it can be claimed that the chief interest of the natives for whom Mootwingee was a sacred home was a small number of the principal foods upon which they depended, and for the increase of which they probably performed ceremonies similar to those of the Lakes tribes associated with the *mura* beliefs, there still remains an overwhelming interest at this site in the emu and the kangaroo. This may be related to the travels of heroes associated with these animals. The set of big pecked intaglios of two kangaroos, emu, bandicoot, and man all belong to a late period of engraving at this site ; whether they form a related composition or not we cannot say, and just what relationship they have to the smaller figures around cannot be determined. The full significance of the widespread importance of the emu and kangaroo in Aboriginal rock art is not yet fully understood.

Linked with the totemic increase rites, and forming another major element in the local rituals, were the travels of the *mura* spirit-beings, which, in the arid interior of the continent, are usually associated with reliable or permanent waterholes. There are several probable representations of these heroes on the Dingo Rock.

Part of the initiation rites would therefore have been for the young men to visit the site and witness the ceremonies, and after their initiation to participate in the rituals themselves. It is unfortunate that the mythology and ceremonies of the Far Western and Corner tribes have not been recorded in detail.

Among other motifs at Mootwingee that might be mentioned are the boomerangs, which occur singly and in vertical sets of from two to four, a practice common to many techniques and phases of rock art in Australia as a whole. The stingray liver (Pl. XXIV., No. 14) probably came from the north, where it is a common motif in the rock art, and not from the south, where it is unknown. The tailed circle, also, is very widely distributed, and no doubt had many meanings in different localities, but the possibility must be considered of its having ultimately been derived from the outline stingray in northern Australian art. The little woman motif, with enlarged vagina represented as a single barred oval, is also known in northern Australian sites, including the upper Yule River (Worms, 1954), Oenpelli (Mountford, 1956), Depuch Island (McCarthy, 1961), and appears to have spread southward. The hollow-bodied men are recorded among paintings in the Kimberleys (Mountford, 1937) and at Conjola, eastern New South Wales (McCarthy, 1959), and among engravings on Depuch Island (McCarthy, 1961).

Sufficient evidence has been presented above to prove that diffusion has played an important part in the corpus of art motifs, styles and techniques in the western New South Wales and Flinders Ranges sites. Similar traits to those in these areas were spreading westward in north-western Australia, as Davidson (1952) pointed out. The point from which the diffusion emanated cannot as yet be decided because of our lack of knowledge of pecked rock engravings in the Northern Territory and the Kimberleys. Sites in central Australia, and on the Drysdale River, and many others, are as yet unrecorded. The available evidence suggests that from the (1) straight abraded grooves this art developed through (2) a simple group of outline animals and circles, tracks, boomerangs, etc., into (3) the elaborate and complex designs of concentric full and half circles, wheel, clusters, line patterns and many others, and finally into (4) the full intaglios of human beings, animals and their tracks.

Another approach that may be considered to enable us to interpret and elucidate designs at such sites at Mootwingee and Sturt's Meadows, where motifs and subjects differ so strongly, is that of Riddell (1928, 15) who thought that all areas had designs peculiar to them, and he cited the little men at Mootwingee as an example. This approach would account for the difference between the naturalistic motifs at Mootwingee and the predominantly symbolic art at Sturt's Meadows as being due to the sites belonging to different local groups, each allied with its own designs and rituals. Mountford (1957, 115) pointed out that certain types of designs tend to be used only in specific localities in the rock art of South Australia, citing human figures in the caves of the Adelaide Hills, circular designs of short lines at Yappala Hills, short lines at Gilmore Well, concentric U or half concentric circle at Mallett, and barred circles at Mt. Chambers Gorge, groupings which he thinks were probably totemic places not necessarily forbidden to the women. At small sites this interpretation is probably true, and at extensive sites like Mootwingee and others it is probable that specific motifs representing the totemic and ritual symbols of a number of local groups were of greater importance than others. It is also reasonable to believe, however, that the manner of representing the totems and cults may have changed during the different phases or periods of pecking distinguished above. New tribes, too, may have moved into an area and introduced their own motifs in the passage of time. When the same motifs are found engraved and painted over such a vast area of the continent as are those in the Abraded Groove, Outline, Linear Design and Intaglio phases of rock engraving, it is obvious that there has been a widespread diffusion of such motifs and that they have served many purposes as ritual symbols. To claim that no change has taken place in the pecked art at these sites would be unrealistic and contrary to the evidence available, because there is abundant data in the spread of the concentric circle *tjuringa* designs into western Queensland (Roth, 1897, Fig. 320), western and north-western Australia (Davidson, 1952) and of the Gunabibi-Djanba ritual and art in the northern Australia (Berndt, 1951, Worms, 1954) to show quite clearly that the tribal art has changed perceptibly, sometimes abruptly, in various parts of Australia in post-white times.

It is apparent that a detailed study is necessary at many sites of the superimpositions of techniques and motifs, and of the range and frequencies of motifs, in pecked engravings generally to elucidate some of the problems discussed above. Work should be directed also towards distinguishing the motifs of the various phases of engraving.

The relationship of the engravings to the paintings at Mootwingee is still indefinite and difficult to decide. Hale and Tindale (1925, 49-52) said that the same subjects are portrayed in both forms of art at Malkaia Springs, Oweiandanna and other sites in central Australia, and that Malkaia Springs ties up the intaglio carvings with the paintings in South Australia. As pointed out above, however, there are also striking differences between the paintings and engravings.

Very little data is as yet available from other sites of paintings in western New South Wales and none for South and Central Australia, about the important problem of superimposition of styles, colours, subjects and techniques. At Blackall (McCarthy, 1958, Fig. 16), in central Queensland, net-like figures form a late phase of painting. In eastern New South Wales stencils belong to the earliest phase of cave art, continuing into the hafted ground-edge axe period, that is, extending from the Bondaian into the Eloueran archaeological periods (McCarthy, 1959). When they ceased to be made is not known. So widespread is the stencil in Australia that detailed studies of its relative chronology are now essential to establish its position in the archaeological history of Australia.

The situation is not clear at Mootwingee. Here, an archaic art of stencilling is the main subject in the caves, concurrent with simple silhouette figures in one colour, and associated with the intermediate and late phases of rock engraving. Some writers (Black, 1943) are of the opinion that the paintings are not as old as the engravings, thus implying that engravings ceased at some indefinite date and that painting was continued until the coming of the white man. A similar idea has been expressed by Davidson (1936, 22) for Australia generally.

A mixed blood Wilyakali man told Elkin (1949, 140) that when he was a boy he did many of the stencillings in red, white and black at Mootwingee, and that there were many places in the district forbidden to women and children. Red and white are the predominant colours in the Mootwingee caves, but there are no stencils or drawings in black in them.

Black (1949, 106) said that he had not found any caves in which both engravings and paintings occur together, but caves 1, 4, 8, 11, 13, 14 and 16 at Mootwingee contain both forms of art, thus indicating that both forms were practised probably by similar people over some generations.

The emu and kangaroo hunting themes are common to both kinds of art, the former being the dominant one in the main gallery of engravings. While the tracks of both animals are common among the paintings and engravings, it is important to note that most of the motifs in the engravings are not painted in the caves where there was an overwhelming pre-occupation with stencilling, an archaic technique and subject for which there is no comparison among the engravings ; but the subjects of the engravings in the caves are much the same as those in the outside galleries.

It is reasonable to argue that the subjects and techniques of the early period of outline and linear engravings, discussed above, may be correlated with the archaic stencilling in the caves at Mootwingee, but the presence of stencilled hafted ground-edge axes negatives this claim because this period of engraving is a pre-axe one. Hence, it can only be stated that at Mootwingee at some unknown period there occurred an emphasis upon pecked engraving, particularly of the full intaglio style, which continued for a very appreciable time. Paintings of the apron and three vertical bars (Big Cave), plant-like figure (cave 19)—all of which are engraved at Sturt's Meadows but not Mootwingee—emu and kangaroo tracks, silhouette of little men, various mammals and lizards, form a link with the engravings. The vertical sets of boomerangs occur among the stencils and also among the intaglio engravings, but this is a motif found in all periods and kinds of rock art in Australia.

From the mythological origin assigned to the engravings at Euriowie, which were said to have been made by the Seven Sisters who went up into the sky to live, Dow (1938, 102) and Barrett (1943, 60) suggested that the engravings in western New South Wales may have been the handiwork of a migration of natives down the Darling River, preceding the coming of those found there by white settlers. This situation may also have existed in South Australia, he thought, where various investigators (except Harney, 1953) have failed to find out anything about the engravings from the natives (op. cit., 149). Basedow (1914, 195) ascertained that when a visitor stated his intention to remove to Adelaide a rock bearing engravings of emu and dog tracks from Myrtle Station, Leigh's Creek, the local blacks destroyed it. Elkin (op. cit., 149) said that " we do know that the revelations made to the initiated consisted of the bullroarer myths, rituals and totemic sanctuaries consisting of heaps of stones, or buried or standing stones. If Aborigines questioned were as ignorant as they claimed and not merely secretive, it is possible that the petroglyphs in this area belonged to an earlier cultural stage before that marked by circumcision and subincision in initiation and by cult-totemism ". He qualifies this opinion by saying that " it may have been the old men's explanation to a young fellow of what they or their fathers did ". These statements were made from the social anthropologist's standpoint and prior to our discovery, as reported in this paper, that there have been several periods of rock engraving in western New South Wales and the Flinders Ranges. Mootwingee is outside the eastern limit of circumcision and subincision, and these customs do not form a cultural stage in the Bandjigali territory. Drawings of ritual head-dresses at Mootwingee appear to belong to the intermediate phase of engraving and there is no direct evidence to prove that increase ceremonies were performed at the site. There are no engravings or paintings of bullroarers. It is not possible to say when the stone heaps (Plate I) were made and used, and although their function could well have been that of totem-centres in cult-totemism, as in north-eastern South Australia (Elkin, 1931) and north-western Australia (Elkin, 1933), the evidence from eastern New South Wales is not clear. Stone heaps occur with the outline engravings, and figures of bullroarers are not uncommon among the Sydney-Hawkesbury district of eastern central New South Wales, where both traits apparently belong to the sky-hero cult ; and although the outline engravings of this area strongly suggest totemism with increase rites, there is no direct evidence in existence to support this claim. Stone heaps are not always symbols of cult totemism, as Elkin (1933) and others (McCarthy, 1940) have shown.

Davidson (op. cit., 20) said that " in north Australia the natives profess ignorance of the carvings in the two sites where they have been noticed, although it is interesting to note that at Delamere they have ready interpretations consistent with explanations of similar figures in their paintings. It could be argued from this that they may be rationalising ancient carvings on the basis of the meanings of their own paintings, but it is nevertheless true that there is a basic similarity between the two, and this fact suggests a continuity of art tradition in this area. At all events, the carvings are no longer made ".

Elkin (op. cit.) suggested that the engravings of western New South Wales may have been made at the time of the migration of the sky hero Ngurundere down the Darling River into the Yaralde country, and further, that they may be connected with the *mura-mura* cults. But we now have four periods of engraving to consider, and unless the mythology becomes more fully known, or archaeology supplies more data, correlation of engravings and cults will remain speculative.

It is doubtful whether the art of the sky-hero cult of south-eastern Australia is the source of the intaglio naturalistic art of the late phase at Mootwingee. It must be remembered that a drastic change was taking place in the art of south-eastern Australia (McCarthy, 1953). On the carved trees, weapons, skin cloaks, and initiation grounds of the Bora type, the concentric diamond, half diamond, and triangle, with parallel chevron and straight grooves, had become the paramount art. Its only recordings so far in rock art are several painted designs at Gundabooka (Black, 1943, Pls. 123-4) and The Meadows in central-western New South Wales, and a design on an engraved bird at Wollombi in the Sydney-Hawkesbury district (McCarthy, 1949, Pl. E., Fig. 1). There may be other examples not yet recorded. The important point to note, however, is that the concentric line figures in the engravings at Sturt's Meadows and Koonawarra and further

west are circles and half-circles, typical of the central Australian region, with none of the diamond and half-diamond figures. As this latter series of formal motifs was apparently replacing the older naturalistic art in south-eastern Australia, the situation was the direct opposite to that in western New South Wales and central and north-western Australia, where the naturalistic designs had replaced the complex line type. The intaglio naturalistic engravings appear to have diffused from the north through the central South Australia region and thence into New South Wales.

Our final conclusion is that at Mootwingee we have a site at which the stencil, silhouette and linear paintings cannot be separated by a study of the superimpositions. These archaic and simple techniques are associated at this site with three distinct phases of rock engravings, the Outline, Linear Design and Intaglio groups, one of which is the latest and most advanced on the continent. It is not possible to say as yet when either painting or engraving ceased in the area, but from the evidence of the implements obtained from cave 14, the beginning of both forms of art have a considerable antiquity. The superimpositions in western New South Wales reveal that the sequence of techniques and subjects is the same in South Australia and north-western Australia.

STONE MOUNDS

Two large and two small mounds of stones lie along a 20° bearing, between 120 and 240 yards north of the Main Engraving Gallery (Plate XIX and map). Each has an identical type of conformation, a kidney-shaped oval the long axis of which lies along an east-west line. The stones are so arranged that a deep trough in the middle is bounded by heaped-up perimeteral walls of which, in each case, the southern convex wall is the highest, dropping uniformly via the convex side walls to a low northern concave wall, suggesting an opening, either entrance or exit, at the most concave part of the northern wall.

The largest mound is the most southern and is situated in a shallow basin-like depression on the plateau. The mount is 70 ft. in circumference, its southern wall is 4 ft. high and its northern wall 2 ft. high.

The second largest is the most northern and is situated on a pebbly ridge of the plateau. It is 60 ft. in circumference, its southern wall is 3 ft. high and its northern wall 1 ft. 6 in. high.

The two smaller mounds are intermediate in position between the two larger ; they are 22 ft. in circumference, their southern walls are about 18 in. high and their northern walls about 9 in. high. They are being broken down by sheep and goats running over the plateau.

Mounds of this kind are widely distributed in western New South Wales (Black, 1950), both in association with engravings and with complex patterns of stones in lines and other shapes, and they also occur separately and in sets. Their function in the life of the Mootwingee tribes is unknown.

However, the identical conformation and relation to the cardinal points of the four mounds at Mootwingee indicate at least that they were deliberately so constructed by the Aborigines.

STONE IMPLEMENTS

The Mootwingee area is studded with surface camp-sites. There are many of them on the banks of the creeks and on the flats through which Nootambulla Creek and its tributaries run. There are other camp-sites along the ridge followed by the main road back to Mootwingee Station, but those along the creeks on this property, in the vicinity of the paintings, were not as productive of implements as were those on the Nootambulla Creek flats. Most of them are along the tributaries of Nootambulla Creek, not along the main creek itself. Series of interest extend along the front of caves 5 to 14, and up Giles Creek to within 100 yards of the main gallery of engravings.

An excellent series of flake and blade implements was collected on camp-sites scattered all over the plateau north of Big Cave (see map). There are patches of soil carrying copses of trees all over this plateau, including pine and other species from which seeds were collected by the women for making into flour dampers. Many broken millstones were noted on these sites.

The camp-sites on the Nootambulla Creek flats and the above plateau have not, apparently, been collected on very intensively in the past, as enquiries at the National Museum of Victoria and the South Australian Museum revealed that neither Museum possesses surface collections specifically localised as Mootwingee. The camp-sites on Mootwingee Station and on the plateau in front of the Big Cave were probably the least disturbed until our visits. A few collectors have visited Mootwingee, and station people looking for their sheep have wandered all over the area. It is therefore impossible at this date to make a reliable analysis of the full range of implements, and of their frequencies, from Mootwingee generally.

Barrett (1929, 416) found an axe of unusual shape in the mud and ashes of a mound beside a pool above the main gallery, the mound he refers to evidently being a fireplace. Mr. H. M. Hale, Director of the South Australian Museum, has informed us that his Museum has no ground-edge axes or cylcons from Mootwingee, and that Dr. MacGillivray's collection of cylcons and axes in this Museum is loosely labelled Menindie. MacGillivray was one of the first naturalists to visit Mootwingee, and he may have collected implements of these types there. Mr. A. Massola, Curator of Anthropology at the National Museum of Victoria, also reports that there are no axes or cylcons from Mootwingee at that Museum, nor does the Australian Museum possess any axes from there. It is obvious that axes are rare in the area. Station hands often pick up the larger implements, like axes, cylcons, millstones and mortars, and we have no record of what implements of these types have been collected at Mootwingee in this manner.

We noted broken millstones on most of the camp-sites, and collected two complete examples—one a roughly flaked slab of local fine-grained sandstone 22 x 11 x 3 in. in size, used on both sides, the other a well made oval pecked example 19 x 10 x 3 in., used on one side. They were found near the base of the rocky ridge in which caves 16 to 21 are situated on Mootwingee Station. Mullers are plentiful, but mortars and pestles, and hammerstones generally, are scarce.

We collected a pecked sandstone cylcon, without any markings on it, in a creek bed (see map).

There is an inexhaustible supply of pebbles, from which the implement materials were derived, which lie in heaps and scattered aggregations all over the rocky outcrop and in the creek beds. This abundant source of stone undoubtedly added to the importance of Mootwingee in the eyes of the Aborigines.

Our collection of 430 nuclei, blocks, normal flakes and blades, points and microliths is a representative one. *Horsehoofs* are well represented among the nuclei, and trimmed blocks were found in normal numbers. In the normal flake and blade group the *tula* adze, with both *tula* and *Burren* type slugs (the latter as usual much scarcer than the former), formed the basis of the industry, in which there is a wide variety of scrapers on tongue-shaped blades and other flakes, and knives (none of the *Leilira* type), and a few burins. *Pirri* points were found all over the area, and among them are some of the unilateral *Adelaide*-type points. Microlithic scrapers, including thumb-nails, are abundant. A wide variety of geometrical types was collected, but as a group these implements are not abundant in the area.

EXCAVATIONS

Out of the 21 shelters containing paintings, only four contained floor deposits. When excavated, these all proved to be shallow.

The most productive site was cave 14. This had a flat floor deposit 10 ft. long and wide, consisting of a shallow over-burden of red sandy clay from 1 in. to 3 in. thick, lying on a grey ashy-sand deposit in which were found several fireplaces of fine black ash. The deposit began at the bottom of the wall at the back of the shelter, and became progressively thicker towards the middle of the floor. Four feet from the wall a deeper section of deposit filled a trough up to 18 in. deep in the rock floor. Trenches 2 ft. wide, dug the full length and width of the deposit in 1958, yielded four *tula* adze slugs, a geometrical microlith, and portion of a millstone. A further excavation of an area 7 ft. x 6 ft. was made in 1959, from which the following series of implements was recovered :—

		1–6 in.	7–14 in.	15–18 in.	
Scrapers :	side	4	3	2	9
	end	1			1
	double-side (reversed)		1		1
Tula adze :		3	2	1	6
Tula slug :		13	2	2	17
Burren slug :		3		1	4
Geometrical Microliths :	triangle	2			2
	trapezoid	1	1	1	3
	peaked semi-circle	1			1

		1–6 in.	7–14 in.	15–18 in.	
Burin :	scaled	1			1
	plain		1		1
Core :	irregular	1			1
Block :	oval crown	2			2
	concave : end and side	1	1		2
	fragments	5	1		6
Microlithic scrapers :	side	2	1		3
	end		1		1
	thumbnail	4		1	5
	core fragments	2			2
	end and side (crown)	1			1
Millstone :	(flaked)	1			1
		48	14	8	70

The majority of the implements came from an area between 2 in. and 14 in. deep. The deepest part of 15 in. to 18 in. occurred at the bottom of the trough. About one-third of the implements are microlitic in size. The scrapers and *tula* range from $\frac{7}{8}$ in. to $1\frac{3}{8}$ in. long, and the slugs from 13/16 in. to $1\frac{3}{8}$ in. long. The bigger oval block is $2\frac{3}{4}$ x 2 x $1\frac{1}{2}$ in. in size. Two of the *tula* slugs are true microliths $\frac{3}{4}$ in. long, another one $\frac{7}{8}$ in., and a *Burren* slug is 15/16 in. The scaled burin is a perfect example of its type, $\frac{7}{8}$ in. long.

The specialised types of implements, which include the *tula* and its two slugs, and the microlithic scrapers, are evenly distributed throughout the deposit. The industry found in this shallow homogeneous deposit may be regarded as belonging to one cultural horizon.

The apron or ledge outside this cave is a slight slope 30 ft. wide, and implements were collected all over it for the full length of the cave, which is also 30 ft. long. This area is covered thickly with small pebbles and broken quartz, among which were found *tula* adze blades, *tula* and *Burren* slugs, a quartz geometrical microlith, and a variety of scrapers some of which are of microlithic size.

Cave 9 had a floor deposit 8 ft. x 3 ft. in size, of a grey to black ashy-sand from 6 in. to 9 in. thick. It yielded part of the rim, a piece 3 in. x 2 in. in size, of a millstone, but no other implements.

Four areas were dug out in cave 15, which is 106 ft. long and 30 ft. wide. Sections, 6 ft. x 4 ft. in size, of grey ashy-sand 6 in. to 9 in. thick yielded few unused flakes only. Along the drip-line were found two *tula* slugs, a microlithic discoid scraper, and a microlithic end and side scraper. Lying on the surface was found a large mortar 13 x 10 x 2 in. in size, made from a slab of local sandstone; it has a working depression on both sides.

Similarly, the deposit in cave 16 was sterile, but along the drip-line were found several *tula* adze-slugs, a small discoid scraper, and untrimmed chips.

Thus, the range of implements from the rock shelter deposits is the same as on the surface camp-sites in the normal flake and blade and microlithic series. This range links the site with the Pirrian phase of the Devon Downs (Hale and Tindale, 1930) and Fromm's Landing (Mulvaney, 1960) sites. Radiocarbon dates (for which charcoal has been collected) will decide whether the Mootwingee site belongs to the early, middle or late phase of the above periods. That this phase may be of some antiquity is revealed by the fact that the geometrical microliths are prehistoric in the Lower Murray Valley, where they were used between approximately 5000 and 3500 B.P. years ago (Mulvaney, 1960, 72, 78). The *tula* and its slugs were used continuously from the Tartangan, with a mid-point dating of 6020 B.P., through the Pirrian phases of the Devon Downs and Fromm's Landing sites in the Lower Murray Valley.

Although no ground-edge axes are known from the Mootwingee area, evidence is available to show that later lithic cultural elements existed in the district. We collected a pecked cylcon and a pecked millstone, and noted broken pieces of other pecked millstones and mullers. They raise the problem of whether or not the intermediate linear phase of engraving is linked with the cave art and implements, and the late intaglio engraving with the cylcon and millstones, as they are all fully pecked.

Thus, a key problem to be solved respecting Mootwingee is the correlation of the cave paintings and rock engravings with the stone implement cultures. Periods or horizons exist in both the engravings and implements, but our data are as yet insufficient to decide their relationships.

SEQUENCE OF WORK, AND ACKNOWLEDGMENTS

One of us (F. D. McC.) spent a week at the site in October, 1955, when Mr. Geoff Johnson, a Trustee of the Australian Museum, kindly provided transport and funds for a Museum research party to visit far western New South Wales. Both authors together visited this site and Sturt Meadows in April-May, 1958, in company with Messrs. O. le M. Knight, D. Walker, I. Stewart and V. Bolton, of Sydney, who assisted in implement collecting, site finding and in excavating caves 15, 16 and 9, which were sterile in implements, and cave 14, where an exploratory trench revealed implements. Both authors again visited the site in November, 1959, in company with Mr. G. Williams, Laboratory Technician, Department of Anatomy, University of Sydney, who assisted in a second more extensive excavation of cave 14, in taking Hornex impressions of rock engravings and in making compass surveys of the total terrain. On this occasion also Mr. George Dutton, our Aboriginal informant, was interviewed in Wilcannia. Our thanks are expressed to the Deputy Commissioner of Police in Sydney, Mr. N. Allan, and to Sergeant E. Madden and Constable M. Salisbury, of Wilcannia, for locating Mr. Dutton and for providing facilities for the interviews and recording.

One of the authors (N. W. G. M.) and Mr. G. Williams returned to Wilcannia in March, 1961, and again in July, 1961, to obtain more information from Mr. Dutton and to re-check the terrain. Our thanks are expressed to Sergeant F. M. Marshall and Constable J. Donohue, of Wilcannia, for similar help. Our thanks are also due to a number of pastoralists for their assistance and kindness ; these include Mr. Lee Smith, of Mootwingee Station, Mr. and Mrs. A. R. Bevan, of Sturt Meadows, Mr. and Mrs. W. Gaul, of Langawirra, Mr. and Mrs. R. Langford, of Waterbag, Mr. and Mrs. F. Barraclough, of Boorungie, and also the Barrier Field Naturalists' Club, through its President, Mr. T. P. Hackett.

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In technical work, Text Figs. 3-9 were arranged by F. D. McC., the line drawings for which were made by Miss Jannelle Bailey, technical assistant, Australian Museum. Plates 1-14, Text Fig. 2 and the map were prepared by N. W. G. M. Photographic reconstruction and printing of all illustrations were prepared by Mr. G. Williams, and the typescript was prepared by Miss A. Scot Skirving and Miss B. Mackel, Department of Anatomy, University of Sydney.

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EXPLANATION OF PLATES

PLATE XIX.—Fig. 1 : " Big Cave " and the plateau. Fig. 2 : From the top of " Main Gallery " looking south to ridge containing caves 5-14. Nootambulla Creek flats and site of surface implements in the middle. Figs. 3 and 4 : Stone mounds north of " Main Gallery ". Fig. 5 : Caves 15-17 (see map). Fig. 6 : " Main Gallery ". Note the angle of slope and the fracture crevices isolating the slabs. Fig. 7 : Do. Note also trees growing in the fracture crevices, and the boulder superimposed on one slab (Dingo Rock). Six smaller rocks intervene between the boulder and the underlying main slab, leaving a space between the two. Fig. 8 : Illustrates the magnitude and nature of the fractures. The depths of the crevice reveal a fresh unbroken surface. Lamination of the slabs can be seen.

PLATE XX, Dingo Rock—Fig. 1 : Shows the engravings occupying the lower two-thirds of the slab. The fissuring of the surface is well demonstrated. The composition of massed figures includes repetition of several motifs. Fig. 2 : Shows the slab with a superimposed boulder ; two small sections of rock, presumably derived from this boulder, lie end-on in the crevice at its south-western margin. Note the blackened south-eastern surface. Figs. 3 and 4: Show motifs similar to those on Dingo Rock, but they are on adjacent surfaces separated by the fractures at the south-west margin of Dingo Rock.

PLATE XXI—Five examples of repetitive portrayal of single motifs : Fig. 1 : Identified by informant George Dutton as a Rain-Making Group. Fig. 2 : Tiny men with tall conical head-dresses identified as *kungulada*, of south-west Queensland, by George Dutton. Fig. 3 : Tiny female figures. Fig. 4 : Barred hollow-bodied men. Fig. 5 : Some hundreds of various tracks, said by George Dutton to represent an incident from the Eaglehawk-Crow Myth.

PLATE XXII—Repetitive examples of a particular motif (emu egg) throughout the Galleries.

PLATE XXIII—Repetitive examples of a particular motif (kangaroo and kangaroo tracks) throughout the Galleries. There are also various portrayals of humans and weapons.

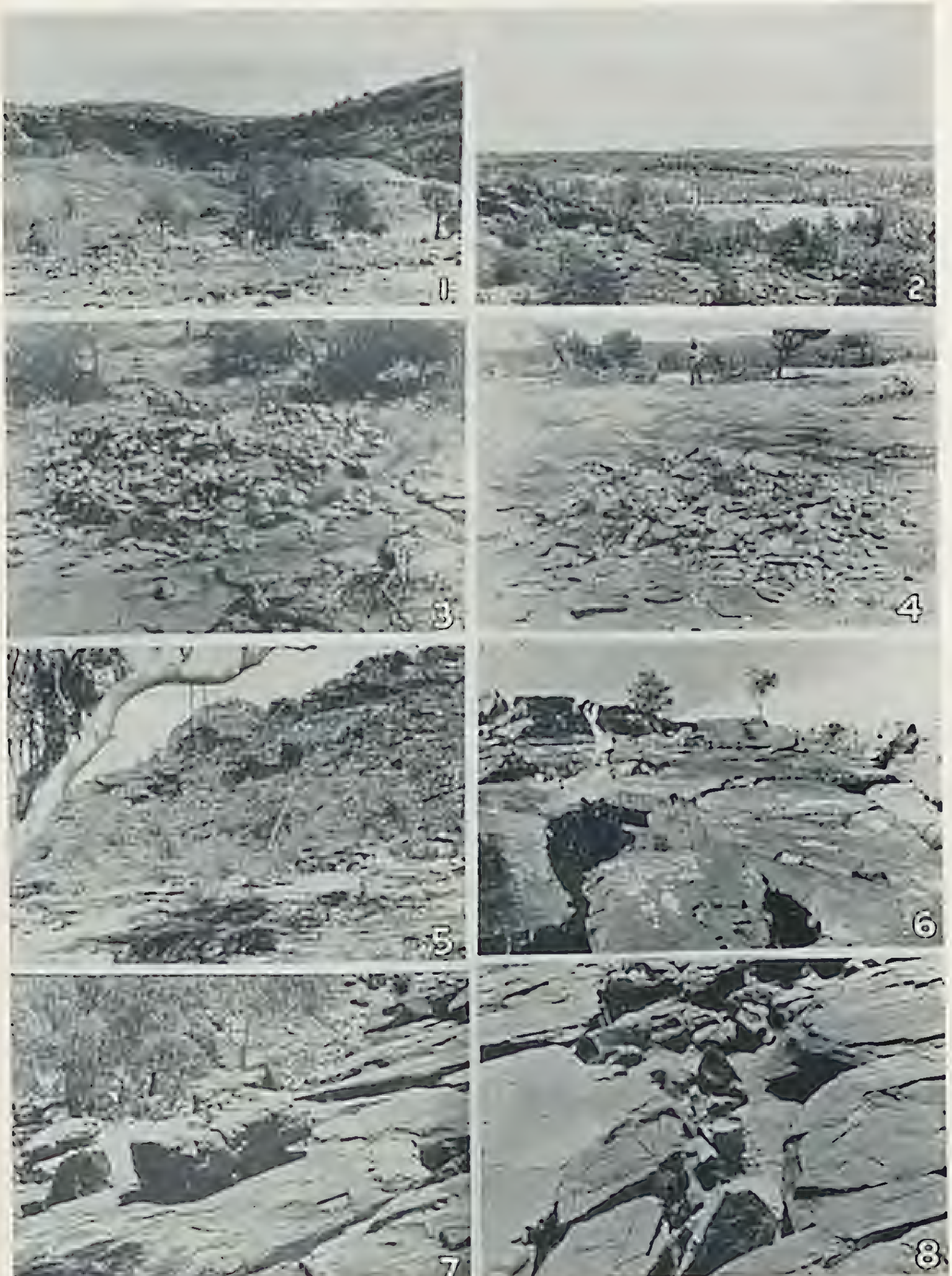
PLATE XXIV—Motifs which are scarce at Mootwingee occurring sporadically on the Galleries.

PLATE XXV—Unchalked illustrations of various pecked figures.

PLATE XXVI—Illustrates some of the superimpositions recorded at Sturt Meadows and described in the text.

PLATE XXVII—Varieties of the dingo motif described in text : Nos. 1 and 2 illustrate the Cult Hero or *mura* ancestor on Dingo Rock. No. 1 is a photograph, distorted by obliquity, of the completely chalked-in rock engraving. No. 2 is an orthogonal photo of a Hornex impression, free from distortion. Collectively, the two cover the text description. No. 3. Mr. George Dutton, our informant. No. 4. Three standing dingoes, one (?) sitting dingo, and one (?) dingo sniffing right foot of armed man. No. 5. Engravings chalked in outline only. No. 6. Orthogonal photo of Hornex impression. Group includes one item identified as snake and one as dingo. No. 7. Isolated engraving of dingo showing five legs or four legs and a penis.

Sydney: V. C. N. Blight, Government Printer—1962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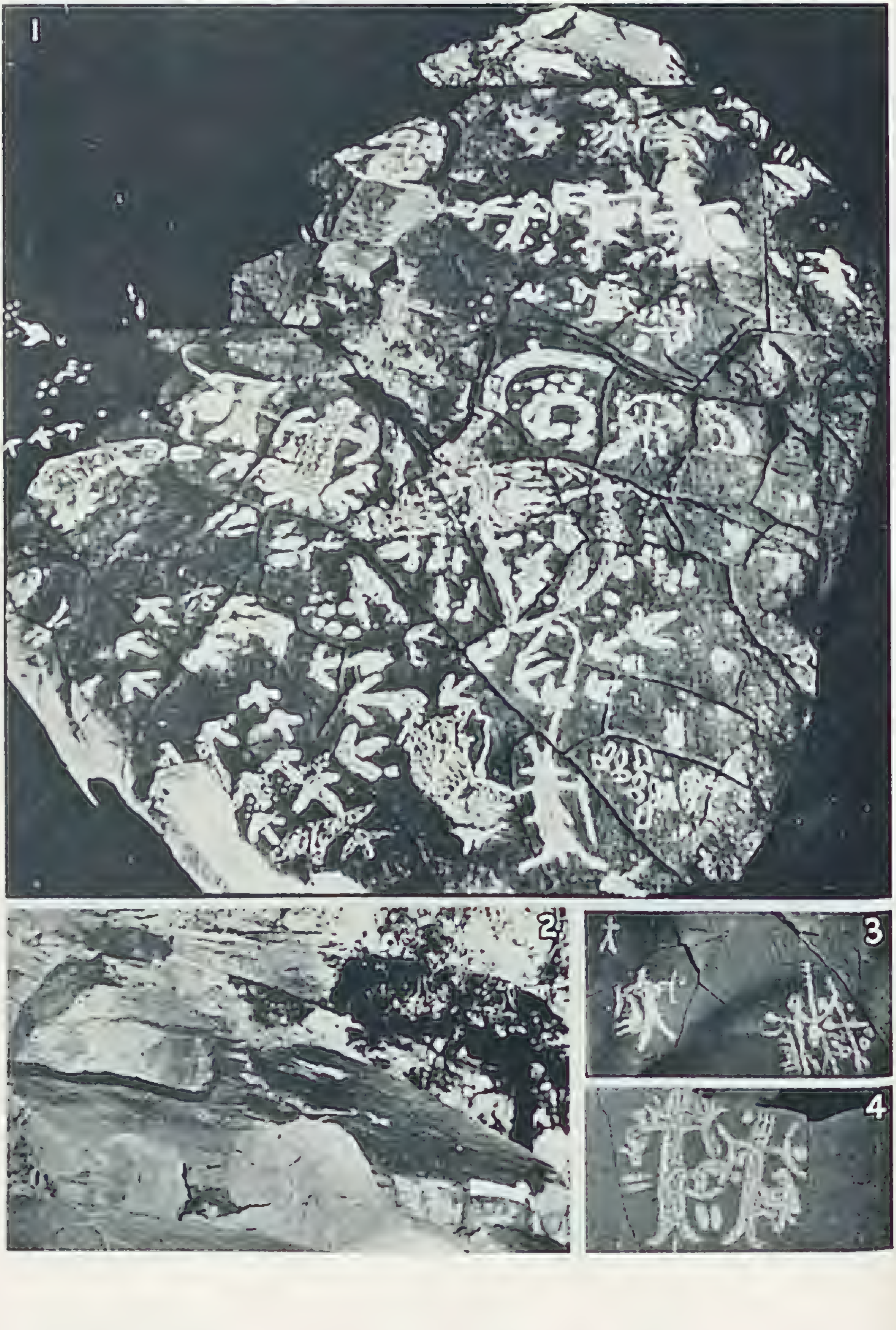
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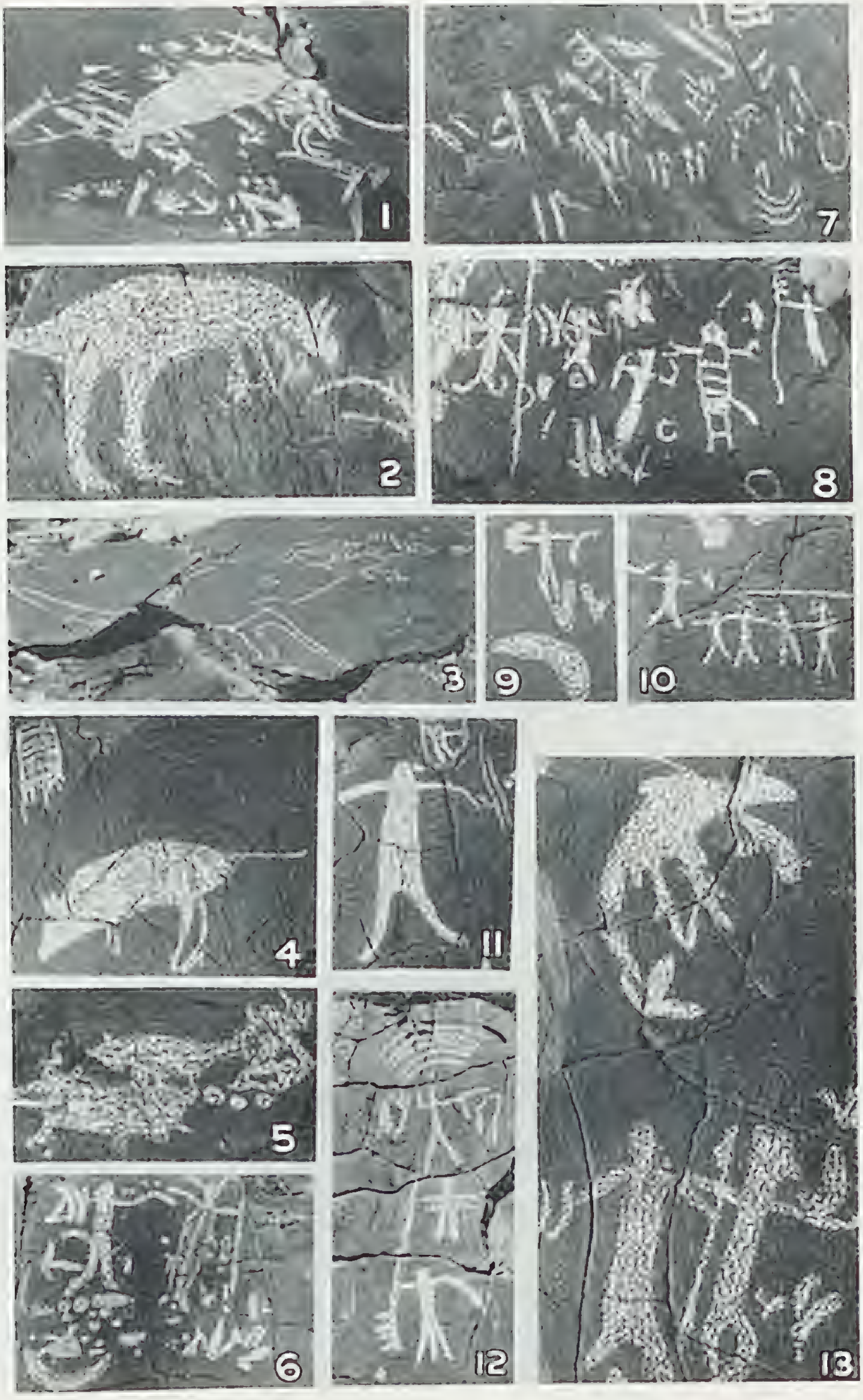
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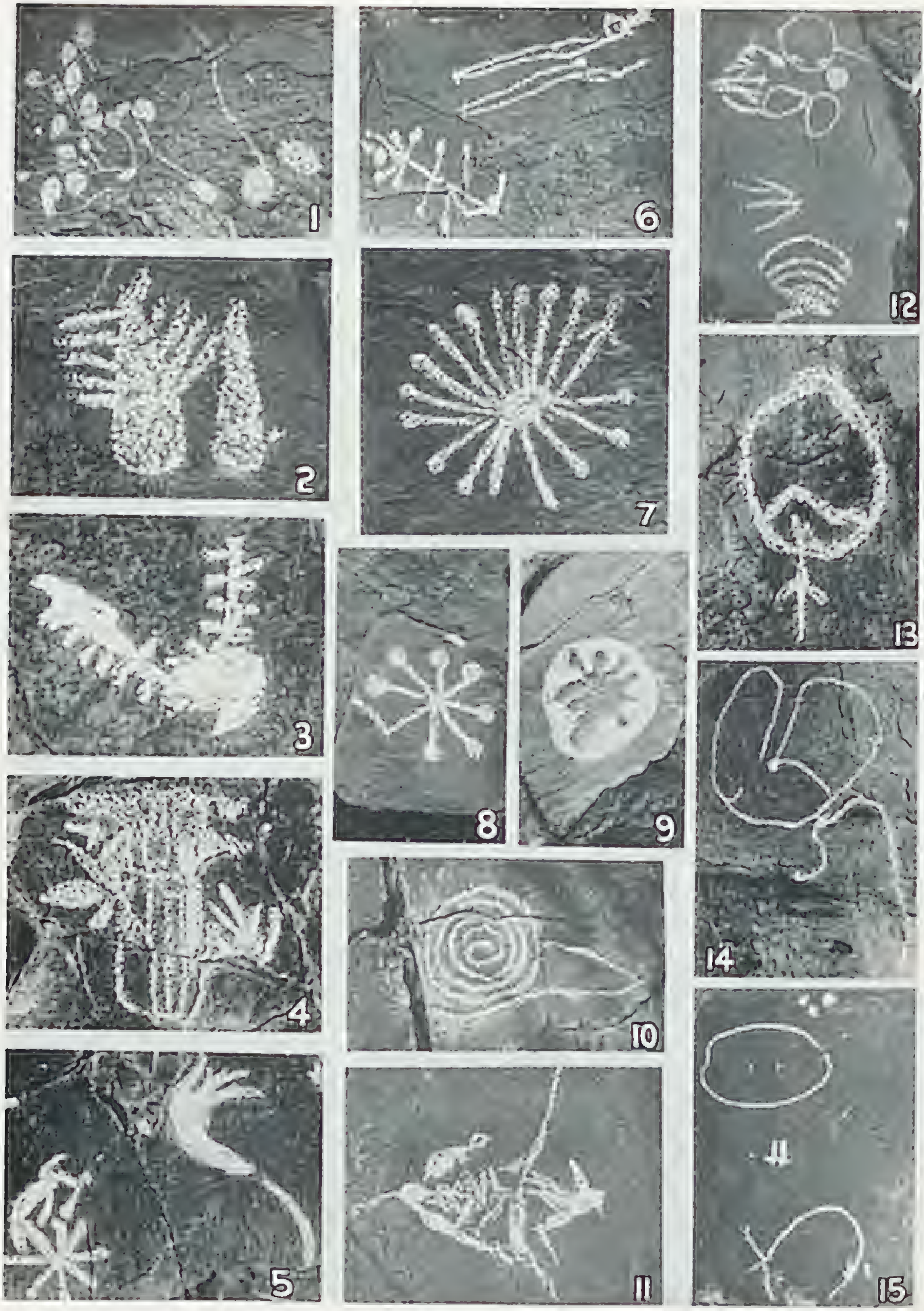
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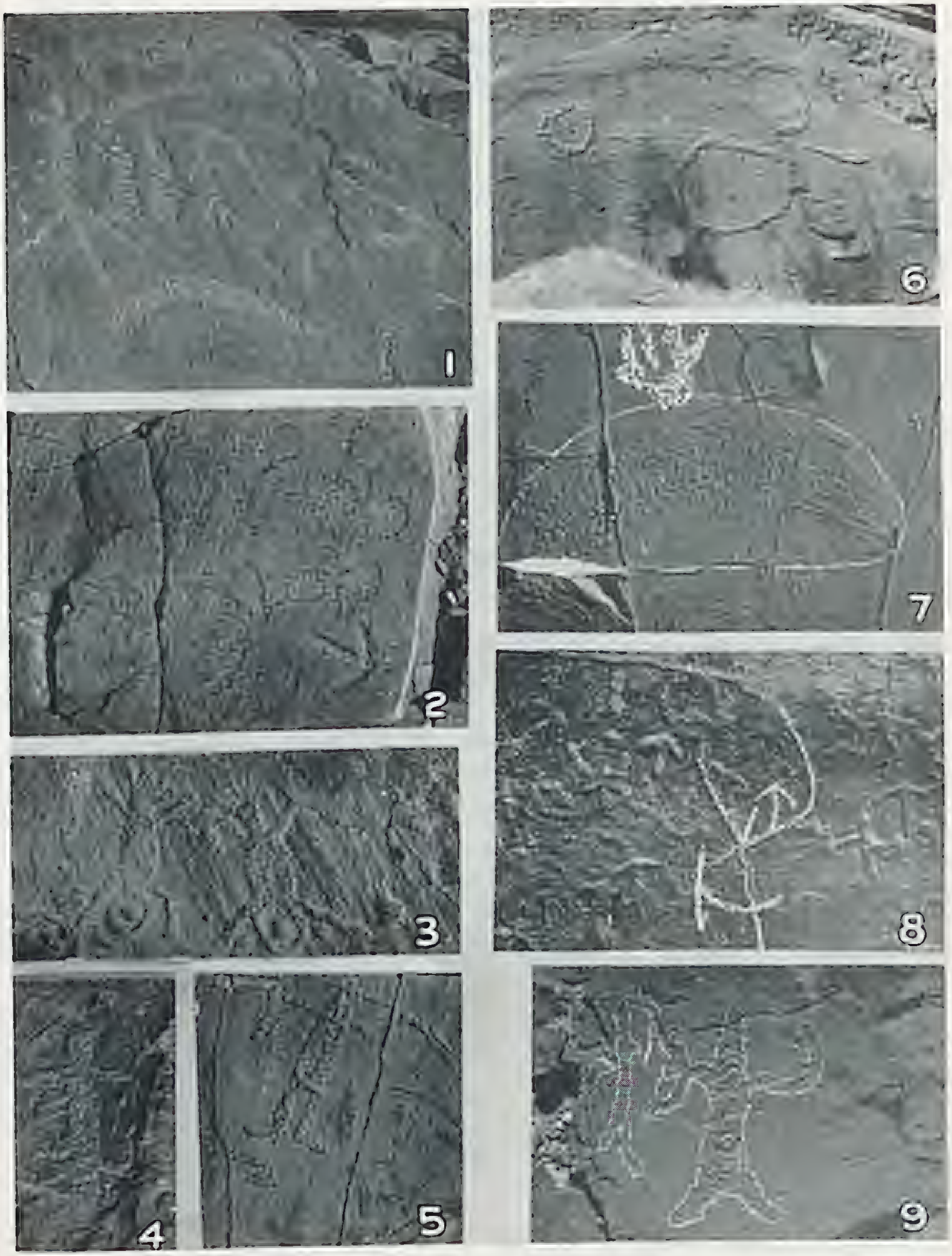
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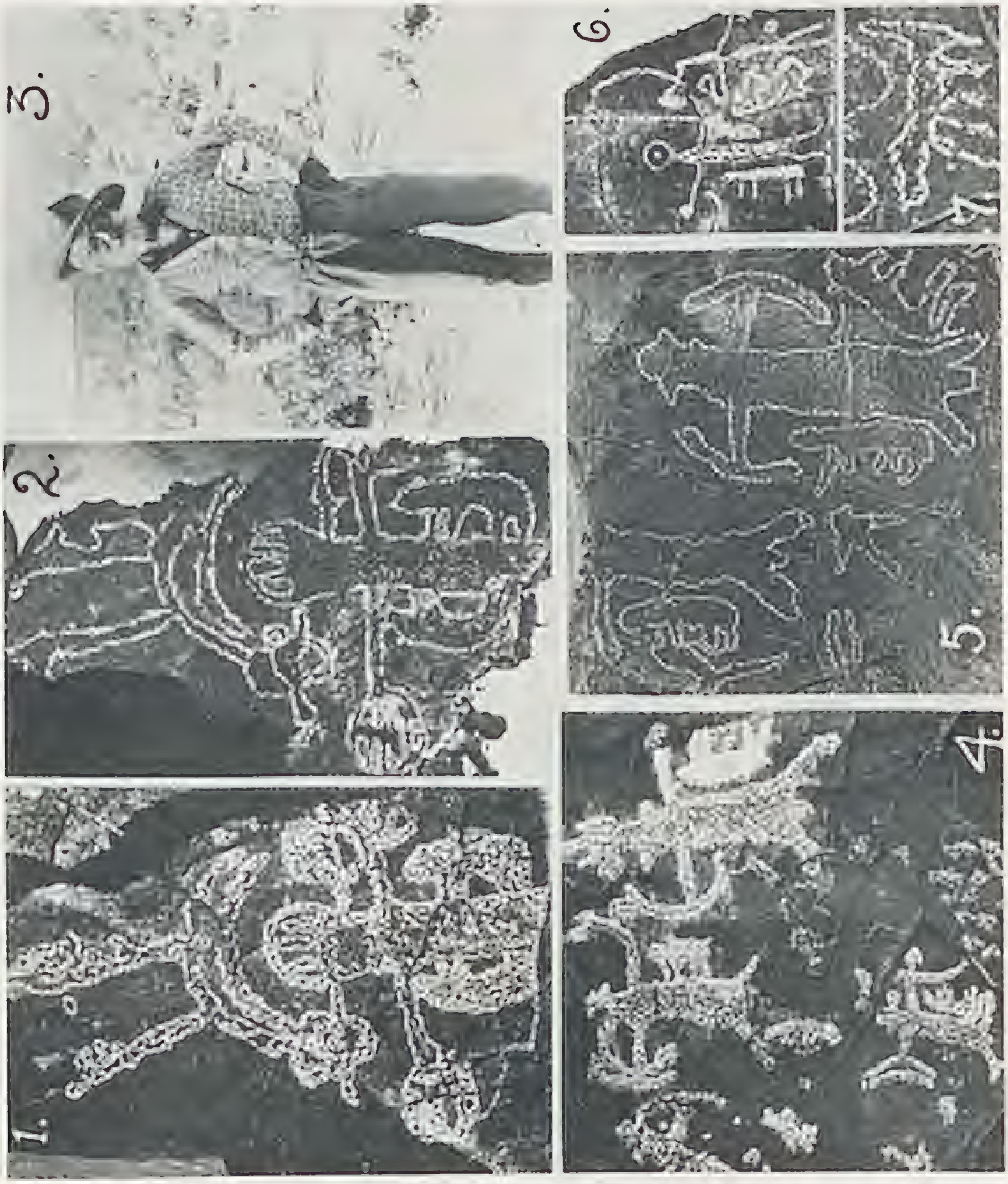
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A New Species of Sthenurus (Marsupialia, Macropodidae) from the Pleistocene of New South Wales

A contribution from the Museum of Paleontology, University of California, U.S.A.

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(Fig. 1)

Manuscript received 5.6.62

ABSTRACT

A new species of *Sthenurus*, *Sthenurus andersoni*, is described from the Pleistocene Bingara fauna of New South Wales, Australia. The holotype is a left mandible, lacking the ascending ramus. Fourteen paratypes and three referred specimens were also used in the description. *S. andersoni* appears to be closely related to *S. atlas*.

INTRODUCTION

The genus *Sthenurus* is represented by three species in the Bingara fauna from Murchison County, New South Wales, Australia (Marcus, 1962, unpublished Ph. D. dissertation). The holotype and paratypes of *Sthenurus andersoni*, the most abundant species of the genus, are from a quarry deposit excavated by the Department of Mines of New South Wales in 1887. William Anderson (1890) directed the collection of the specimens and described the deposit.

Sthenurus andersoni, is similar to, but smaller than, *S. atlas* (Owen), 1838. Its lower molars are lower crowned, shorter and relatively wider than those of *S. atlas*. *S. andersoni* and *S. atlas* represent long-jawed members of the genus, whereas *S. oreas* and *S. pales*, both represented at Bingara, and *S. occidentalis* from Western Australia are short-jawed (more like *Procoptodon* in this respect). *Sthenurus* molars maintained sharp crests throughout all wear stages. In *Procoptodon* they are worn off to form triturating surfaces. Propalinal motion would be restricted in *Sthenurus* by the interlocking of the upper and lower molar crests.

The clay deposit in which the Bingara fauna occurs is of limited extent and overlies late Tertiary or early Quaternary basalts. Hundreds of specimens were excavated from this deposit and these represent five families of marsupials. Mandibles of macropodids are the most abundant fossils. *Diprotodon optatus*, *Thylacoleo carnifex*, *Macropus titan*, and *Zygomaturus trilobus* are associated with *Sthenurus andersoni* at Bingara and the Wellington Caves in New South Wales, and at the Darling Downs in Queensland. These species were elements of a widespread middle to late Pleistocene fauna.

ACKNOWLEDGEMENTS

The author was a member of the University of California Museum of Palaeontology expedition to Australia in the summer of 1954, and was supported by that institution for continued research in Australia until January, 1955. Dr. R. A. Stirton arranged for the loan of specimens from the Australian Museum, Sydney. The collections, notes and diagrams that he made were constantly used during the preparation of this paper. Oliver Chalmers and Harold Fletcher, of the Australian Museum, gave invaluable assistance in the assembling and shipping of the extensive Bingara collection to the University of California. The illustrations were prepared by Augusta Lucas.

DESCRIPTION OF FOSSILS

Sthenurus andersoni*, Marcus, n. sp.

Holotype.—Left mandible, Australian Museum no. MF 946. Ascending ramus lacking; angle partially lacking; root of $I_{\overline{2}}$, P_{3}, part of alveolus and anterior root of $M_{\overline{1}}$, and $M_{\overline{2-4}}$ preserved; Bone Camp Gully, V5572.

Paratypes†.—Bone Camp Gully, V5572: Left mandible, $P_{\overline{3}}$, $M_{\overline{1-2}}$, MF3. Right mandible, $P_{\overline{3}}$, $M_{\overline{1-3}}$, UC 60015. Right mandible, $M_{\overline{2-2}}$, UC 60016. Right mandible, $I_{\overline{2}}$, $P_{\overline{2}}$, $DP_{\overline{3}}$, $P_{\overline{3}}$ excavated from its crypt, MF 10. Left mandible, $M_{\overline{2-4}}$, MF 942. Left mandible,

* For the late Charles Anderson (1876-1944), of the Australian Museum, who before his death curated and was studying a large part of the Bingara collection.

† V and UC numbers refer to v rtebrate localities and specimens, respectively, of the University of California Museum of Paleontology; MF and F numbers refer to specimens in the Australian Museum.

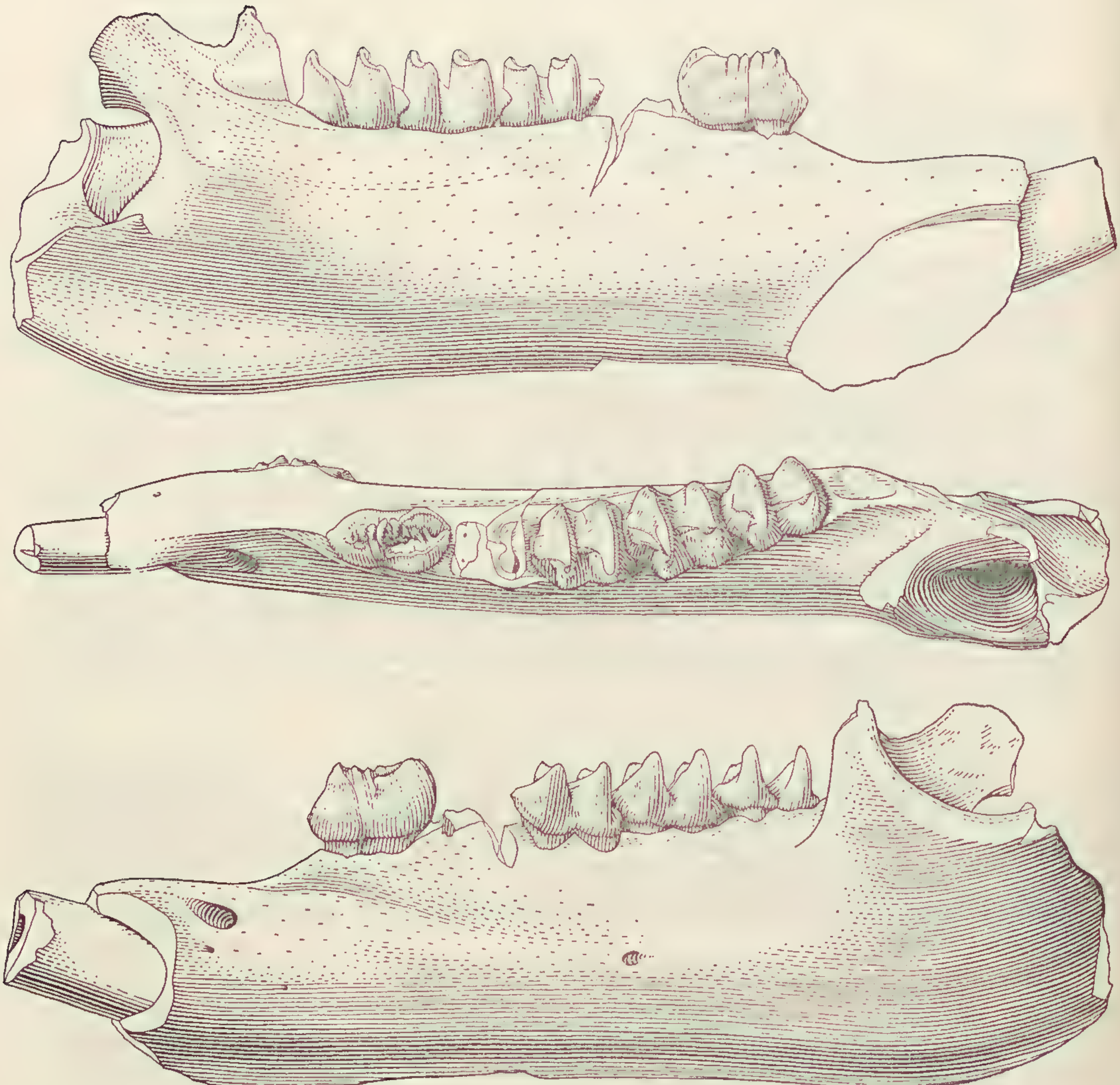

Fig. 1: *Sthenurus andersoni* Marcus, new species. Holotype, left mandible, incisor broken off, $P_{\overline{3}}$, $M_{\overline{1}}$ missing, $M_{\overline{2}} - M_{\overline{3}}$. Natural size. Aust. Mus. MF 946. Top, lingual view. Centre, occlusal view. Bottom, labial view.

$M_{\overline{2}-\overline{3}}$, protolophid of $M_{\overline{4}}$, MF 1078. Left mandible, hypolophid of $M_{\overline{2}}$, $M_{\overline{3}-\overline{4}}$, MF 1137. Right mandible, $P_{\overline{3}}$, $M_{\overline{1}-\overline{2}}$, roots $DP_{\overline{3}}$ and $M_{\overline{3}}$, UC 60006. Right $P_{\overline{3}}$, UC 60005. Right $M_{\overline{2}}$, F 49661. Right M^{3}, F 49662. Left DP^{3}, F 49663. Right M^{1}; right M^{2}, UC 60008.

Referred specimens.—Wellington Caves, New South Wales, V5538: Left mandible, tip $I_{\overline{2}}$ broken off, $M_{\overline{1}-\overline{4}}$, angle and part of masseteric canal preserved, MF 39. Maxillary fragment, P^{3} exposed in its crypt, M^{1-4}, MF 21.

Lake Menindee, New South Wales, V5371: Ankylosed mandibles, left $P_{\overline{3}}$, $M_{\overline{1}-\overline{4}}$, right side broken at mental foramen; associated premaxillary with bases of upper incisors, right M^{1}, UC 45673.

Specific diagnosis.—Long-jawed member of the genus, smaller than *S. atlas*, its closest relative; lower molars smaller, lower crowned, with lower links than in *S. atlas*; lower premolar shorter and narrower posteriorly than *S. atlas*; median groove at anterior end of labial crest of $P_{\overline{3}}$ shallower and less conspicuous than in *S. atlas*, in which this groove reaches nearly to base of tooth; median groove at anterior end of labial crest shallow, and does not separate the two crests in early and medium stages of wear as in *S. atlas*.

Type locality.—The west side of Bone Camp Gully, a tributary of Ironbark Creek, 15 miles east of Bingara, New South Wales, Australia. On the fifth edition of the Lands Department Map, August, 1946, Parish of Durham, the locality is in Portion 176, the property of Mr. Michael R. C. Fleming*.

Age.—Pleistocene.

Fauna.—Bingara.

DESCRIPTION†

Upper molars.—Two of the three upper molars may come from the same individual, as they fit closely together and are of the correct relative wear. A left DP^{3} came from a younger individual and is only slightly worn. The molars have a simple pattern without forelinks and only weak midlinks from the protocones to the centres of the metalophs. The anterior cingulum forms a shelf a little narrower than the protoloph which curves abruptly into the paracone and more gradually to the protocone. The paracone and metacone are almost connected by flanges forming a labial crest which nearly closes the labial end of the median valley. The median valley is sharply grooved to the base of the root lingually, but is more U-shaped in M^{3} than in M^{1} or M^{2}. The lophs are broader than the lophids of the lower molars. They diverge more towards their bases. The wear surfaces are concave posteriorly. A fold formed by the hindlink is present on the posterior surface of the metaloph as in *Macropus*. Fine ridgelets may be present on the surface of the teeth.

Measurements in Millimetres

Dimension	UC 60008 right M^{1}	UC 60008 right M^{2}	F 49662 right M^{3}
length	11·0	13·0	13·6
width protoloph ..	11·2	12·8	13·0
width metaloph ..	11·8	12·8	12·4

Mandible.—The body of the ramus is slimmer and not as deep as in *S. atlas*. The lower border is rounded and the lingual surface from below $P_{\overline{3}}$ to $M_{\overline{3}}$ is convex. The disgastric ridge starts below the hypolophid of $M_{\overline{3}}$ (holotype of MF 946). Viewed from the lingual side, the alveolar border and lower border are nearly parallel, diverging only posterior to $M_{\overline{4}}$ (MF 5 and MF 946). The symphysis is not highly rugose and does not extend behind the geniohyal pit as in *S. oreas* or the other short-jawed members of the genus. The diastema is as long as in *S. atlas* with the mental foramen slightly posterior to the midpoint between $P_{\overline{3}}$ and $I_{\overline{2}}$ as in that species. The anterior border of the symphysis forms approximately a 15 to 20 degree angle with the alveolar border.

The upper border of the angle is about 10 millimetres below the alveolar plane. The massseteric canal is large and communicates with the mandibular canal by a large foramen which is visible internally above the edge of the masseteric fossa. Two small foramina are present on the anterior end of the ridge separating the mandibular and masseteric canals in MF 5 and MF 946. The ascending ramus is perpendicular or at slightly greater than a right angle to the alveolar line, and begins behind $M_{\overline{4}}$, except in younger individuals where it is more anterior.

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* Military grid reference 378303, Ordinance sheet Inverell, New South Wales, H56/5, Zone 8, second edition 1942; Scale 1:253440.

† The description is based on the types and referred specimens.

Lower dentition.—$I_{\overline{2}}$ Only one incisor was associated with a mandibular fragment, MF 10, in the Bingara material. Though this incisor has been glued in, its fit is so perfect that this does not appear to be a fortuitous association. This incisor is barely worn, with its blade thickening below. The dentine surface extends forward into the outer and internal enamel surfaces. The lower edge curves upward sharply toward the tip. Wear is exclusively on the upper edge of the blade where the wear surface is at a 15-degree angle to the axis of the tooth. The broken $I_{\overline{2}}$ in MF 39 from Wellington Caves is worn considerably and its tip broken off. The enamel is very thin of the lingual surface of $I_{\overline{2}}$ in MF 39, and there is a facet on the lower lingual border which is worn smooth from contact with the opposite $I_{\overline{2}}$

$P_{\overline{2}}$ is represented by only one specimen, which is moderately worn, exposing dentine (MF 10). It has a lingual crest subdivided by a mid-vertical groove, and what was probably a labial crest separated by a groove. Both grooves reached the base of the tooth. Finer details cannot be discerned, though this tooth is smaller and appears less complex than its counterpart in *S. atlas.*

$DP_{\overline{3}}$ is molariform and heavily worn in the single example available for study, MF 10. The lophids converge to a V lingually and labially in the median valley. The midlink is prominent in this well-worn tooth. The labial wall of the protolophid slopes slightly medially.

$P_{\overline{3}}$—Seven examples of this tooth are preserved, four unerupted and unworn. The premolar is two-rooted with the smaller root anterior. It is small compared to that of *S. atlas* (see table). A bulge above the roots forms a cingulumlike structure on the anterior half which may bear a small cuspule on its anterior edge, as in UC 60006. This structure may continue posteriorly. The main features of the crown are a lingual crest divided into 6 cuspules, the last three of which may be less distinct, and a shorter crescent-shaped posterolabial crest which usually connects to the lingual crest by one or more tranverse ridgelets. The lingual cuspules may be split longitudinally (UC 60015) and the anterior one may be more complex. The labial crest is smooth and undivided; in MF 10 the posterior part is set off by a small vertical ridge. The valley between the main crests may have ridgelets on the labial side. The transverse ridges may bifurcate into two branches lingually (UC 60005) and (UC 60015), be double (MF 946), or the bifurcation may be almost absent (MF 10)*.

Molars.—The molars increase in size from $M_{\overline{1}}$ to $M_{\overline{3}}$. $M_{\overline{3}}$ is longer than $M_{\overline{4}}$ though the protolophid of $M_{\overline{4}}$ may be nearly as wide as $M_{\overline{3}}$. The lophids are narrow and appear as columns viewed from either side, and are separated by broad U-shaped valleys. Their crown surfaces are slightly concave forward, and thus curve slightly posteriorly at their centres from bottom to top. The anterior cingulum shelf is approximately half the width of the tooth. The forelink, which is not strong, proceeds from the protoconid to the centre of the anterior edge of the tooth, where it curves back to form a semicircular ridge on the anterior cingulum shelf. The forelink is very low. Fine ridgelets may be present on the anterior surface of the protolophid. The midlink runs across a raised surface in the centre of the median valley. A small ridge from the entoconid may contribute to this eminence. There is a low posterior cingulum which may be peaked into a vertical ridge labiad of the centre of the hypolophid on the anterior molars. Fine ridgelets may cover the hind surface of the hypolophid. Viewed anteriorly, the lateral surfaces of the lophids are highly convex, so that the maximum lophid width occurs well above the base of the tooth. The line of the molars forms a convex curve anteroposteriorly on the labial side. The crown of $M_{\overline{1}}$ faces slightly labiad, whereas that of $M_{\overline{4}}$ faces slightly linguad expressing a tortion of the tooth row as in *Procoptodon.* The molars are low crowned, (lower crowned than those of *S. atlas*) and the lophids are higher labially than lingually.

TOOTH ERUPTION AND WEAR

In UC 60015, $M_{\overline{4}}$ erupted before $P_{\overline{3}}$ (the $M_{\overline{4}}$ is absent in this specimen, but its alveolus shows that it was in place and had erupted). $P_{\overline{3}}$ must have erupted very shortly after $M_{\overline{4}}$ for it is only slightly worn in MF 5, as in that specimen $M_{\overline{3}}$ is advanced in wear only slightly over that of UC 60015. The crests of the lophids remain sharp in intermediate wear stages, with initial wear concentrated on the posterior edge of the lophids, which form crescentic edges. After additional wear, the lophid crests flatten somewhat and dentine is exposed, first labially and then lingually. In the heaviest worn specimen, MF 1137, dentine is exposed on both lophids of $M_{\overline{2}}$, a little on the corner of $M_{\overline{3}}$ and only on the protoconid of $M_{\overline{4}}$. In that specimen the lophids still retain sharp edges. The teeth of *Sthenurus* appear to be subject to less attrition than those of *Procoptodon.*

* The median groove at the anterior end of the labial crest is shallow and does not separate the two crests in early and medium stages of wear as in *S. atlas.*

MEASUREMENTS OF THE HOLOTYPE AND SUMMARY OF MEASUREMENTS OF THE MANDIBLES AND LOWER CHEEK TEETH OF *STHENURUS ANDERSONI* FROM BINGARA AND *STHENURUS ATLAS* FROM THE WELLINGTON CAVES.

All measurements in millimetres

	Sthenurus andersoni from Bingara						*Sthenurus atlas* from the Wellington Caves					
	Holotype (MF 946)	Summary of measurements*					Holotype (cast)	Summary of measurements*				
Dimension		N	O.R	$\overline{X}$	S	V		N	O.R	$\overline{X}$	S	V
$P_{\overline{3}}$ length	15·7	7	14·4-16·3	15·09	·880	5·83	17·4	4	16·7-17·4	17·12	·341	2·00
width protolophid ..	7·0	7	6·2- 7·0	6·44	·399	6·20	..	3	6·3- 7·0	6·65	·360	5·42
width hypolophid ..	7·6	7	6·6- 7·6	7·03	·411	5·85	9·0	4	8·1- 9·0	8·50	·392	4·61
$M_{\overline{1}}$ length	..	5	11·4-11·9	11·80	·235	2·01	..	3	12·7-13·7	13·10	·530	4·05
width protolophid ..	..	5	8·2- 8·9	8·48	·269	3·16	10·5	4	8·9-10·5	9·62	·692	7·18
width hypolophid ..	..	5	8·5- 8·9	8·74	·152	1·74	10·7	4	9·4-10·7	9·95	·615	6·18
$M_{\overline{2}}$ length	13·8	8	12·5-13·8	13·28	·423	3·19	14·3	2	14·3-14·4	14·35		
width protolophid ..	10·2	8	9·6-10·2	9·94	·199	2·00	11·8	2	10·4-11·8	11·10		
width hypolophid ..	10·2	8	9·7-10·2	9·92	·149	1·50	11·8	2	10·8-11·8	11·30		
$M_{\overline{3}}$ length	14·3	6	12·6-14·3	13·80	·610	4·42						
width protolophid ..	11·3	5	10·8-11·4	11·10	·255	2·30						
width hypolophid ..	11·2	6	10·5-11·2	10·70	·253	2·36						
$M_{\overline{4}}$ length	12·7	3	12·7-13·5	13·00	·356	2·74						
width protolophid ..	11·1	4	10·6-11·3	10·95	·269	2·46						
width hypolophid ..	10·4	3	9·7-10·4	10·07	·287	2·69						
Mandible depth ..	30·3	5	26·4-30·3	27·70	28·12	10·15						
$M_{\overline{2}-\overline{3}}$ width	15·4	5	13·0-15·4	14·42	·876	6·07						

* Statistics: N—sample size; O.R.—observed range; $\overline{X}$—sample mean; s—sample standard deviation; V—sample coefficient of variation as defined in Simpson, Roe and Lewontin (1960).

VARIATION

Measurements for mandible and lower cheek tooth dimensions of the holotype of *Sthenurus andersoni* and of a cast of the holotype of *Sthenurus atlas* are given in the table, together with a summary of measurements for paratypes of each species. The tooth dimensions of *S. andersoni* vary little, as expressed by the coefficient of variation (1·50—6·20). $P_{\overline{3}}$ is the most variable tooth in both length and width. The premolars of *S. atlas* are as variable as in *S. andersoni*, whereas $M_{\overline{1}}$, the only tooth for which there was sufficient data, is less variable in *S. andersoni*. A larger sample of specimens would be necessary to establish the variation patterns with more confidence. The differences in tooth dimensions between *S. atlas* and *andersoni* are significant, except for the anterior width of $P_{\overline{3}}$.

DISCUSSION

Sthenurus andersoni appears to be closely related to *S. atlas*. The type of *S. atlas* is a mandibular fragment of a juvenile containing $DP_{\overline{3}}$, $M_{\overline{1}-\overline{2}}$, with $P_{\overline{3}}$ excavated from its crypt (Owen, 1838; 1874, Plate 22, figure 4). It is from Wellington Caves. *S. andersoni* is smaller than *S. atlas*, with a shorter and proportionately narrower $P_{\overline{3}}$. The body of the ramus is shallower and narrower in *S. andersoni* than in *S. atlas*. The continuation of the forelink into the anterior cingulum shelf on the lower molars is more pronounced in *S. atlas*.

S. atlas has been reported from Balladonia, Eucla Division, Western Australia (Glauert, 1912), but the few comments Glauert makes regarding these specimens suggest a species near *S. oreas* rather than the long-jawed *S. atlas*. *S. atlas* and *S. andersoni* occur together at Wellington Caves and Lake Menindee (Tedford, 1960, unpublished Ph. D. dissertation) in east-central and western New South Wales, respectively. Only *S. andersoni* occurs at Bingara in north-eastern New South Wales. Devis' (1895) description of the specimen he referred to as *S. atlas* from the Darling Downs of south-eatern Queensland are in part suggestive of *S. andersoni*, but apparently include a wide range in morphology and thus probably include more than one species of *Sthenurus*.

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THE AUSTRALIAN AGROMYZIDAE

By KENNETH A. SPENCER

(Figs. 1—78) Manuscript received 7.10.61

SYNOPSIS

The known Australian Agromyzidae have been revised, 24 new species are described and keys are given to genera and species in the 10 genera now known to be represented in Australia. The origin of the 57 species is discussed. No evidence is so far available of any close relationship with South American species and it is concluded that the Australian Agromyzidae have arrived from the north, in at least three distinct waves, the earliest possibly being in the Cretaceous.

INTRODUCTION

The Australian Agromyzidae have hitherto been largely unknown, with a total only of 21 species recorded (Malloch, 1923, 1925, 1927; Hering, 1951, 1962; Kleinschmidt, 1960). This excludes *Fergusonina* spp. which Malloch (1924) and Tonnoir (1937) included in this family, although they are aberrant in a number of features from currently accepted concepts of the Agromyzidae. Hennig (1958) has now raised this group to family rank.

During a month's visit to Australia in January-February, 1961, I was able to make brief collecting trips around Darwin, Brisbane, Sydney, Canberra, Melbourne, Adelaide and in Tasmania and have also been able to study unidentified material from the Australian Museum, Sydney, the Institute of Hygiene and Tropical Medicine, Sydney, the C.S.I.R.O., Canberra, and the Commonwealth Institute of Entomology, London. I was able to examine in Sydney the types of 7 of the 8 Australian species described by Malloch.

In the present paper 57 species are discussed, of which 24 are described as new. Seventeen of the species now recorded for Australia are known from the Oriental region. The biology is known in 30 species and of these 22 are leaf-miners, the others being internal stem-borers (5), gall-causers (2) or seed-feeders (1). No new genus has been discovered. A number of *Melanagromyza* spp. were found, feeding as leaf-miners and pupating in the leaf. The mine in these species is not epidermal but deeper, either upper or lower surface. No other species of this genus are known to feed in this way.

Only 10 genera out of the world total of 22 are represented. All Australian genera occur in the Oriental region, which has only a single additional genus, *Phytagromyza* Hendel, not present in Australia. The close similarity of the generic distribution in Australia and the Oriental region is shown in the following table:—

	Australia		*Oriental Region*	
	Species	*Percentage*	*Species*	*Percentage*
Agromyza Fall	1	1·75	13	16
Japanagromyza Sasakawa	1	1·75	3	4
Melanagromyza Hend.	24	42·1	28	35
Ophiomyia Brasch	6	10·5	4	5
Cerodontha Pz.	3	5·3	1	1
Phytobia Lioy	7	12·3	15	19
Liriomyza Mik	9	15·8	6	8
Phytoliriomyza Hend.	1	1·75	1	1
Phytagromyza Hend.	—	—	1	1
Pseudonapomyza Hend.	1	1·75	4	5
Phytomyza Fall.	4	7	4	5
	57		80	

My own observations made in January-February—admittedly not the best collecting season—suggest that the Agromyzidae are widespread in Australia but not abundant, as, for instance, in Western Europe or parts of South America. It is incorrect, as Paramonov (1959: 175) suggests, that many leaf-mining species of *Agromyza* and *Phytomyza* remain to be discovered. Certainly many new species do still await discovery, but there is no reason to believe they will not be found approximately in the proportions of the species now known, with a continuing dominance of *Melanagromyza.* In two days' collecting in Tasmania, on Mount Wellington and in the Mt. Field National Park, I was only able to discover two species.

The main genera of the Agromyzidae have recently been characterized in detail by Frick (1952), and it is not proposed to recapitulate generic characters here, apart from those given in the key to genera. The scale line of the drawings represents 0·1 mm. for genitalia and pupal spiracles and 0·5 mm. in other cases, except where otherwise indicated. The following abbreviations have been used:—

ors—upper fronto-orbital bristle(s). acr—acrostichals.
ori—lower fronto-orbital bristle(s). dc—dorso central bristle(s).

The dc are numbered forwards, the strongest being referred to as the first.

The location of types of previously described species is indicated as follows:—

Institute of Hygiene and Tropical Medicine, Sydney—IHTM.
Deutsches Entomologisches Institut, Berlin—DEI.
Author's Collection—AC.
U.S. National Museum, Washington—USNM.
British Museum (Natural History), London—BM.
Queensland Museum, Brisbane—QM.
Hungarian National Museum, Budapest—HNM.
Zoological Museum, Amsterdam—ZM.

Collectors are abbreviated as follows: D. K. McAlpine—D.K.M.; S. J. Paramonov—S.J.P.; K. A. Spencer—K.A.S.

ZOOGEOGRAPHY

The distributional pattern of the Australian Agromyzidae can be summarized as follows:—

Endemic (on basis of existing information),	37
Also in Oriental region,	14
Also in Palaearctic region,	2
Also in New Zealand,	1
Cosmopolitan,	3
	57

The two Palaearctic species, *Phytomyza plantaginis* R.-D. and *P. vitalbae* Kalt., almost certainly represent introductions with European colonization. The aedeagus of *vitalbae* is strikingly different from that of *clematidicolla* Spencer, suggesting that the two species are not closely related, although feeding on the same host plant.

Of the 17 species common to the Oriental region, three are the Cosmopolitans *Calycomyza humeralis, Liriomyza brassicae, Phytomyza atricornis*; three feed on cultivated leguminous crops—*Melanagromyza centrosematis, M. phaseoli* and *M. sojae*—and *Pseudonapomyza spicata* occurs commonly on sugar and maize, and there seems little doubt that the natural distribution of these four species has been enlarged by commerce in recent times. *Ophiomyia lantanae* has been deliberately introduced to many areas as a possible aid in controlling *Lantana camara.* Some of the remaining nine species probably form part of the invasion from the north which occurred following the Pleistocene glaciation, when a land connection last existed across the present Torres Straits. Such species may be *Melanagromyza alternata* and *Liriomyza caulophaga*, whose known distribution is limited to South-east Asia and Australia. It seems certain, however, that others are of earlier origin. Two which definitely appear to fall within this category are *M. albisquama* Malloch (= *leguminum* Bezzi) and *M. alysicarpi* Bezzi, which were hitherto considered to be endemic on Fiji. If it is accepted that these two species reached Fiji by land connection and not by fortuitous subsequent crossing of a wide water gap, they provide interesting confirmation of the so-called " outer Melanesian arc ", which, it is postulated, linked New Guinea to Fiji in the Miocene as a series of island stepping stones or even a direct land connection, when many Asiatic species also reached Australia. The wide range of *M. albisquama* across Asia and Africa to the Cape Verde Islands suggests that this is not a species of recent origin.

M. alysicarpi has also been recently confirmed in Java and India. Another such species, which occurs right across Africa and Asia from the Cape Verde Islands to Micronesia, New Guinea, the Solomons and as far as East Santo and Vila in New Hebrides (but has not been recorded in Fiji), is *M. metallica* (Thomson).

The diminutive epidermal miner, *Melanagromyza atomella* (Malloch), which has now been found on numerous hosts in Australia as far south as Clyde Mountain, New South Wales, occurs widely throughout the Oriental region, including Micronesia and New Guinea, also in Southern Japan (as *M. styricicola* Sasakawa); the same species or a close relative also occurs in Africa and Madagascar. This also may well have formed part of the Miocene southward expansion, and it will be interesting to know whether, with further collecting, the species will also be found on Fiji.

The only species common to Australia and New Zealand (apart from the cosmopolitan *P. atricornis*) is *Liriomyza chenopodii* (Watt) (= *imitans* Malloch). This species feeds on cultivated plants such as spinach and beet, and, in view of the total distinctness of the New Zealand Agromyzidae, it is plausible to accept this as a relatively recent introduction by man. Of the 16 New Zealand Agromyzidae listed by Harrison (1959), 13 can be immediately accepted as endemic; this includes *Melanagromyza* sp.n. (confirmed from examination of specimens kindly sent me by Dr. Harrison) referred to by Harrison as *aeneiventris* Fall., a species " recorded " in various parts of the world but which is in fact an Urtica feeder limited to the Palaearctic region. I have also been able to confirm that specimens referred to as *Cerodontha denticornis* Pz. are not in fact the Palaearctic species but are close to *australis* Malloch; however, a distinctive difference in genitalia suggests that the New Zealand specimens represent an endemic species. The ancestor of this species and of *australis* could have reached New Zealand and Australia simultaneously at the time of the " inner Melanesian arc ", which Ross (1956) suggests linked New Guinea to New Zealand at the end of the Cretaceous. Alternatively, if the theory of the Melanesian arcs is not accepted, the New Zealand " *denticornis* " could represent a diverging form of *australis*, which at some time has successfully crossed the water gap from Australia. It should be mentioned here that Darlington (1957) considers that the entire New Zealand fauna, including vertebrates, can be reasonably accounted for without land connections, merely by a slow accumulation of species across the wide water gaps involved.

The origin of the 37 endemic species is less obvious. Some, no doubt, are not in fact endemic and merely await discovery in the Oriental region to the north. A number of the *Melanagromyza* spp. such as *apii* Hering, *placida* sp.n., *seneciophila* sp.n., *specifica* sp.n. and *verdescens* sp.n. closely resemble many typical Oriental species and could belong to this category. Others have presumably evolved from earlier northern immigrants in the Miocene. The non-epidermal, leaf-mining *Melanagromyza* spp., such as *indigoferae* Kl. and *wikstroemiae* Kl., are without parallel elsewhere. *Ophiomyia angustilunula* sp.n. and *O. micra* sp.n., small species with a white squamal fringe, belong to a group well represented in South Africa (Spencer, 1960: 28). *Melanagromyza dianellae* Kl. and *M. paramonovi* sp.n., both with white squamae and fringe, also have a close relative in the southern hemisphere, *M. galactoptera* Bezzi from Mauritius. These two groups have a distinctly Gondwanan distribution. *Cerodontha australis* Malloch appears from the structure of the aedeagus to be more closely related to the northern *C. denticornis* than to *C. flavifrons* (Philippi) (cf. Frick, 1952: 399), from Chile. *Cerodontha robusta* Mall. and *vittigera* Mall. have a peculiarly developed spine on the third antennal segment (fig. 41b) which differentiates them from all other known species in the genus. It is interesting in this connection that both species have been found on Mt. Wilson, N.S.W., where many relict species in other groups occur. *Phytomyza clematidicolla* sp.n. has the same host as *clematadi* Watt, 1924, in New Zealand, and both pupate in the mine. The genitalia (figs. 63 and 68) suggest that these two species are more closely related than either to the northern hemisphere species *vitalbae* Kalt. (fig. 69). There is nothing obviously aberrant in the other endemic species, which in all genera are very similar to species known elsewhere throughout the world.

Paramonov (1959: 187) accepts as self-evident that in a number of families, of which 10 are cited, a close relationship exists between Australian and South American species. Hennig (1960), in the most detailed and scientific study of this problem as affecting Diptera which has yet been made, fails to find conclusive evidence for any New Zealand-Australian-South American link which would have provided a closer relationship between species from Australia-New Zealand and South America on the one hand than with species from the northern hemisphere on the other. Unfortunately, no comprehensive study of Neotropical Agromyzidae has yet been made. I have myself collected in Brazil, Venezuela, Colombia and Jamaica and am familiar with a number of Malloch's (1933) species from Patagonia. Information, however, is still very incomplete, but there is no evidence so far to support theories of a partial southern origin of the Australian species. Assuming an exclusive northern origin—and there is nothing in the existing distribution pattern which cannot be explained on the basis of this assumption—it is a matter of pure conjecture as to which species may have reached Australia during the Miocene and which during a possible earlier land connection in the Cretaceous. The extreme paucity of species so far found in Tasmania supports the theory of a northern origin.

KEY TO GENERA OF THE AUSTRALIAN AGROMYZIDAE

1.	Subcosta developed throughout its length, coalescing with r1 before reaching costa ..	2
	Subcosta becoming a fold distally and ending in costa separately and basad of r1	5
2.	Prescutellar bristles present	3
	Prescutellar bristles lacking	4
3.	Three or more pairs of dc present	*Agromyza* Fallén
	Only two pairs of dc present	*Japanagromyza* Sasakawa
4.	Facial keel between antennae prominent	*Ophiomyia* Braschnikov
	Facial keel, if distinguishable, narrow and flattened	*Melanagromyza* Hendel
5.	Two scutellar bristles, distinct spine or angle at upper corner of third antennal segment	*Cerodontha* Rondani
	Four scutellar bristles	6
6.	Orbital setulae erect or reclinate, sometimes weak or absent	7
	Orbital setulae proclinate, well developed	9
7.	Costa strongly developed to vein m1 + 2	8
	Costa extending only to vein r4 + 5	*Pseudonapomyza* Hendel
8.	Scutellum same colour as mesonotum, black or grey	*Phytobia* Lioy
	Scutellum yellow, at least centrally or apically	*Liriomyza* Mik
9.	Costa extending to vein m1 + 2, vein mm. present	*Phytoliriomyza* Hendel
	Costa only reaching vein r4 + 5, vein mm. absent	*Phytomyza* Fallén

Genus **Agromyza** Fallén

Agromyza Fallén, 1810, Nov. Dipt. Dispon. Method. p. 21, No. 66.

Type species *Agromyza nigripes* Meigen, Europe.

Only a single species of this widespread genus has been recorded in Australia, *A. testacea* sp.n., described below. The leaf-miner on *Oplismenus* referred to on p. 339 almost certainly belongs here. Even accepting two species the genus appears to be significantly less numerous than in the Oriental region.

Agromyza testacea sp.n.

Head: very large, frons one and a quarter times width of eye, slightly projecting above eye in profile anteriorly; two strong ors (missing on both sides but detectable from large basal pits), two strong ori, directed inwards and upwards the lower slightly weaker, orbital setulae sparse, reclinate; ocellar triangle not defined beyond foremost ocellus; orbits scarcely differentiated, lunule small and low, at right angles to plane of frons; jowls narrow, one-tenth height of eye; cheeks linear; vibrissa strong, equal to lower ori; eye exceptionally large, almost round, third antennal segment slightly longer than broad, rounded at end, very finely pubescent above, arista conspicuously long, equal to vertical height of eye.

Mesonotum: 3 + 1 strong dc, third and fourth equal, equidistant each side of suture, prsc well-developed; inner post-alar slightly shorter, acr short, irregular, in some eight rows in front, extending to prsc.

Wing: Length in female 2·8 mm., costa extending to m1 + 2, rm at midpoint of discal cell, last and penultimate segments of m4 equal.

Colour: frons sooty black, small shining areas round basal pits of orbital bristles, first and second antennal segments black, third paler, more brownish; mesonotum matt black, with no trace of grey, abdomen more shining black, legs entirely black, wings clear, veins brownish-black, wing base dark brown, squamae grey, fringe black, halteres yellowish.

Holotype: ♀, N. Queensland, Kuranda, 20.xii.1958 (D.K.M.), Australian Museum, Sydney.

A. testacea is readily distinguishable from the two species from the Oriental region having a distinct pre-scutellar dc:

A. flavisquama Malloch, 1914 (Formosa), has a pale squamal fringe, and a new species shortly to be described from Thailand has a shining black mesonotum and conspicuously yellow wing base.

Genus **Japanagromyza** Sasakawa

Japanagromyza Sasakawa, 1958, Sci. Rep. Saikyo Univ. (Agr.) 10: 140.

Type species: *Agromyza duchesneae* Sasakawa, 1954 a, Japan.

This small genus consists of 14 world species, of which one new species is described below; three additional species will be described shortly, from New Guinea, New Hebrides and Thailand. Known distribution is limited to the Ethiopian and Oriental regions (Spencer, 1961 and 1961a), Japan, Micronesia, (Spencer, in press), New Guinea and New Hebrides.

The Australian species is the first true Agromyzid known to feed on Eucalypts. A species widespread in Asia and Japan, *J. variihalterata* (Mall.), 1914, is a blotch-miner on cultivated leguminous crops, such as *Glycine* and *Pueraria*, and might be expected to occur in Queensland.

This genus is readily recognizable by the presence of two strong dc, together with well developed pre-scutellars or a distinct postero-lateral bristle on the fore-tibia.

Japanagromyza eucalypti sp.n.

Head: frons narrow, equal to width of eye, not projecting above eye in profile; two strong equal ors directed upwards; two ori, upper weaker than ors, directed upwards, lower smaller, directed inwards; orbital setulae distinct, in single row, reclinate; ocellar triangle small, inconspicuous, scarcely differentiated; lunule small, semicircular; jowls narrow, deepest at rear, cheeks linear, third antennal segment rounded, with slight upturned pubescence; arista long, bare.

Mesonotum: two pairs of dc, second at level of supra-alar, three-quarters length of first, prsc somewhat weaker than second dc and equal to intra-alar; inner post-alar distinct but slight; acr in some eight rows in front, ending at prsc.

Wing: length in male 1·9, in female 1·9 to 2·2 mm.; costa extending strongly to vein m1 + 2; rm at basal third of discal cell, last segment of m4 two thirds length of penultimate.

Legs: mid-tibiae with two strong postero-dorsal bristles, fore-tibiae with one weaker but distinct bristle.

Colour: frons matt, sooty-black, orbits weakly shining; ocellar triangle scarcely so; lunule silvery-grey; remainder of head black; mesonotum shining black, appearing slightly more greyish, matt, when viewed from front; abdomen shining black; legs entirely black; wings clear, veins dark; squamae grey, margins and fringe black; halteres with dark stalk but entirely white knobs.

Male genitalia: aedeagus (fig. 1a) ending in long tubule, distinctive ventral appendage, as figured; spermal sac small (fig. 1b).

Puparium: orange-red, segments well defined, largely smooth; posterior spiracles trifurcated (fig. 2), each arm with some 12 buds, 6 along each side.

Holotype ♂, N.S.W., Lisarow, bred 23.ii.1958, ex leaf-mine in *Eucalyptus camaldulensis* Dehnhardt found 6.ii.1958; 5 paratypes, Lisarow: one ♀ same data as holotype, one ♀ 10.iii.1958 on tips of same host; one ♂, two ♀, bred 26-27.ii.1961 ex leaf-mines on same host found 3.ii.1961 (all K. M. Moore). Holotype in Australian Museum, Sydney; paratypes: two in British Museum (Natural History), two in collection of Forestry Commission, N.S.W., one in author's collection.

This is the first true Agromyzid known to feed on any species of Eucalypt. It closely resembles *insularum* Spencer (in press) from Micronesia, but is readily distinguishable by the more shining black mesonotum; the aedeagi of the two species are entirely different. Other species in which the larva has a similar arrangement of posterior spiracles are *J. variihalterata* (Malloch), 1914 (*Glycine*, *Pueraria*), *J. elaeagni* (Sasakawa), 1954a (*Elaeagnus*) and *J. quercus* (Sasakawa), 1954a (Quercus).

Genus **Melanagromyza** Hendel

Melanagromyza Hendel, 1920, Arch.f. Natg. for 1918, 7: 14.

Type species *Agromyza aeneiventris* Fallén, Europe.

This is the dominant genus throughout the Ethiopian and Oriental regions, Madagascar and Australia. By contrast it accounts for only 5 per cent. of the species in the Palaearctic region. Eight new species are described below; leaf-mines or empty puparia found in stems of three undescribed species almost certainly referable to this genus are discussed under Unidentified Species, p. 339 and a further apparently undescribed species is discussed on p. 322.

Known Australian species are leaf-miners or internal stem-borers; elsewhere the larvae have also been found to feed as seed-eaters and gall-causers. A distinctive group of minute epidermal leaf-miners, causing a conspicuous whitish mine, hitherto known from the Ethiopian and Oriental regions, is well represented in Australia. In my opinion, in this group there is one dominant, highly polyphagous species, *M. atomella* (Malloch) (= *styricicola* Sasakawa in Japan), and two further species in the group, *M. cassiae* and *M. murrayae*, are described below.

The genitalia drawings below confirm the close phylogenetic relationship of many of the species. On the other hand, there is a striking difference between the aedeagus of *atomella* and *cassiae*, two morphologically similar epidermal leaf-miners which appear not to be very closely related. *M. dianellae* and *M. paramonovi* closely resemble *Ophiomyia angustilunula* and *O. micra*, but in the two former species the aedeagus is strikingly different from the typcial Ophiomyia pattern of the latter.

KEY TO AUSTRALIAN MELANAGROMYZA SPECIES

1. Squamal fringe pale, white or ochreous 2
   Squamal fringe dark, black or brown 13
2. Orbital setulae proclinate .... *bowralensis* sp.n.
   Orbital setulae reclinate 3
3. Mesonotum entirely shining black 4
   Mesonotum distinctly greenish 7
4. Abdomen black, similar to mesonotum 5
   Abdomen shining green .... *sojae* (Zehntner)
5. Large species, wing length 2·7 mm. .... *alternata* Spencer
   Small species, wing length at most 1·9 mm. 6
6. Jowls narrow, one-tenth height of eye, wing length 1·6 mm. .... *dianellae* Kleinschmidt
   Jowls broader, one-quarter height of eye, wing length 1·9 mm. ...... *paramonovi* sp.n.
7. Arista appearing bare 8
   Arista distinctly pubescent 11
8. Large species, wing length at least 2·5 mm. 9
   Smaller species, wing length at most 2 mm. 10
9. Mesonotum shining green, third antennal segment conspicuously round .... *apii* Hering
   Mesonotum more blackish, only faintly greenish, third antennal segment longer than broad .... *seneciophila* sp.n.
10. Lunule narrow, higher than semicircle .... *verdescens* sp.n.
    Lunule in form of semicircle .... *specifica* sp.n.
11. Eye in male bare .... *albisquama* (Malloch)
    Eye in male distinctly pilose 12
12. Eye in female distinctly pilose .... *piliseta* (Malloch)
    Eye in female virtually bare .... *metallica* (Thomson)
13. Mesonotum with 3 pairs of dc .... *trispina* (Malloch)
    Mesonotum with 2 pairs of dc 14
14. Ocellar triangle greatly elongated, brilliantly shining .... *phaseoli* (Tryon)
    Ocellar triangle not so 15
15. Mesonotum conspicuously matt .... *wikstroemiae* Kleinschmidt
    Mesonotum at least somewhat shining 16
16. Third antennal segment with long whitish pubescence 17
    Antennal pubescence normal 18
17. Minute species, wing length in male 1·3 mm. jowls narrow .... *indigoferae* Kleinschmidt
    Larger species, wing length 2-2·4 mm., jowls broader, one-sixth height of eye .... *conspicua* Spencer
18. Last and penultimate segments of vein m4 equal 19
    Last segment of m4 distinctly shorter than penultimate 22
19. Large species, wing length 2·4 mm., jowls broad, one-fifth height of eye ...... *sp.* (N.S.W.)
    Smaller species, wing at most 1·7 mm. 20
20. Costa extending at most to midway between veins r4 + 5 and m1 + 2 .. *alysicarpi* Bezzi
    Costa extending strongly to vein m1 + 2 21
21. Arista bare; jowls broad, one-sixth height of eye .... *pisi* Kleinschmidt
    Arista distinctly pubescent; jowls narrow, one-tenth height of eye ...... *murrayae* sp.n.

22. Jowls relatively broad, one-sixth height of eye, arista virtually bare .. *centrosematis* de Meij.
    Jowls narrower, one-tenth height of eye 23
23. Arista distinctly pubescent .... *atomella* (Malloch)
    Arista appearing bare 24
24. 4 ors, 2 ori, distance separating cross-veins equal to length of vein mm. ...... *placida* sp.n.
    2 ors, 2 ori, distance separating cross-veins greater than length of mm. ...... *cassiae* sp.n.

Melanagromyza albisquama (Malloch), comb.nov.

Agromyza (*Melanagromyza*) *albisquama* Malloch, 1927.

Melanagromyza leguminum Bezzi, 1928, syn.nov.

Melanagromyza minora Spencer, 1959 (synonymized with *leguminum*, Spencer, 1961c).

Location of holotype: IHTM.

Malloch described this species from a single caught male from N.S.W., Eccleston. I have compared this specimen with the type of *leguminum* Bezzi from Fiji, and it is clear that the two are synonymous. I therefore synonymise *leguminum* with *albisquama* herewith. Further specimens have been examined from north Queensland.

Essential characters of the species are as follows: frons not projecting above eye, ocellar triangle broad, not elongated, lunule in form of semi-circle, jowls one-tenth height of eye, third antennal segment distinctly shining, with extremely short pubescence, arista long, distinctly pubescent (fig. 3a), eye in male bare; mesonotum and abdomen shining greenish, squamae and fringe white; wing length 1·6 to 2·2 mm.; *M. leguminum* was bred from " pods of No. 51 C.T.W."; the species has recently been discussed by Spencer, 1961c and in press; the aedeagus of a specimen from Palau was illustrated by Spencer (in press, fig. 5).

Distribution.—N.S.W.: Eccleston; north Queensland: Atherton Tableland, Head of Clohesy River; Fiji, Micronesia, Indonesia, South Africa, Cape Verde Islands.

Melanagromyza alternata Spencer, 1961

Location of holotype: DEI.

One male, Otford, N.S.W., 26.i.1951 (D.K.M.). This specimen has been compared with the hitherto unique female holotype from Formosa.

This is a relatively large species with wing length of 2·6 mm. and has an entirely shining black mesonotum and abdomen without any trace of sheen, combined with white squamae and fringe; the eye in the male is haired; no other species is known with this combination of characters.

The aedeagus is shown in fig. 4.; the ninth sternite has an exceedingly long hypandrial apodeme, similar to that in *seneciophila* (fig. 26).

Distribution.—N.S.W.: Otford; Formosa. New to Australia.

Melanagromyza alysicarpi Bezzi, 1928

Location of holotype: BM.

This is one of the smallest shining black species, with wing length of 1·5 mm. in male and 1·6 mm. in female. It is readily distinguishable by the costa terminating shortly after vein r4 + 5; it is also separable from the *centrosematis* group by the last two segments of vein m 3 + 4 being equal.

The aedeagus is illustrated in fig. 5; the distiphallus consists of a large sac-like structure covered with conspicuous sensory pores, as found in a number of species in the genus.

The puparium is pale white with large, black anterior spiracles, similar to those in *atomella* and with the posterior spiracles in the form of two widely-separated projections, dark at the base and each bearing distally three pale buds.

The larva forms a distinctive, white, leaf-mine (fig. 6) in *Alysicarpus vaginalis* DC, primarily along the midrib with smaller branches along the stronger lateral veins; the puparium remains on the midrib with the anterior spiracles projecting through the leaf epidermis.

I found the mines to be relatively common on the host-plant at Darwin, Northern Territory, on 22.i.1961, and again on 16.ii.1961. The species was described from the same host on Fiji. Prof. Hering has mentioned that he has leaf-mines, which he can now refer to this species, on *A. nummularifolius* (L.) from Java. I have also seen young mines in *A. vaginalis* from Madras, India, in the Herbarium at Kew which almost certainly belong to the same species.

Distribution.—N. T.: Darwin; Fiji, Java, possibly India. New to Australia.

Melanagromyza apii Hering, 1951

The larva of this species mines in the petiole and midrib of *Apium graveolens* L., and it must be considered a pest on cultivated celery; described from Sydney.

The adult belongs to the large complex of metallic greenish species and can be briefly characterised as follows: frons at most slightly projecting above eye; jowls relatively broad, one-sixth vertical height of eye; third antennal segment distinctly round, arista bare, eye bare in both sexes; mesonotum and abdomen shining green, possibly with bluish tinge; squamae and fringe white; wing length up to 2·7 mm.

The posterior spiracles of the larva are separated by approximately their own diameter and consist of a ring of 9 or 10 buds enclosing a strongly chitinised horn. The pale brown puparium remains in the mine at the base of the leaf. The adult has been recorded in November-December, and in April-May. Hering (1951) illustrates the male genitalia and larval characteristics.

Distribution.—N.S.W.: Mascot and Bronte, near Sydney, Mona Vale, Jenolan; South Australia: Athelstone.

Melanagromyza atomella (Malloch)

Location of holotype: HNM.

Agromyza atomella Malloch, 1914.

Melanagromyza atomella (Malloch), Hennig, 1941.

Melanagromyza styricicola Sasakawa, 1954a, syn. nov.

Agromyza euonymi Kuroda, 1954.

Melanagromyza polyphyta Kleinschmidt, 1960, syn. nov.

This species is a highly polyphagous epidermal leaf-miner, occurring widely from India to Micronesia, including Japan, and now found to be common in N.S.W.

Malloch's description is based on caught specimens, and, although he established 20 paratypes, I have found that only one specimen of this series agrees with the holotype. Subsequently silvery, epidermal mines have been found on numerous plants in Java, Japan, India, Ceylon, Guam and Australia, but in view of the limited material available it has hitherto been difficult to decide whether a number of closely related species were involved or whether the virtually identical mines were caused by one widespread, polyphagous species.

I have recently reviewed this problem in the light of the additional material I have collected and received from other sources, and have also re-examined the types from Formosa, kindly lent me by the Zoological Museum, Budapest. The following facts can now be recorded:—

1. Until recently it was thought that *styricicola* was distinct from *atomella*, in view of the generally larger size. Specimens bred from *Passiflora foetida* L. and *P. suberosa* L. in Ceylon have a wing length of up to 1·6 mm. (Spencer, 1961) and the same size is normal in a lengthy series from Guam (Spencer, in press), whereas in Japanese specimens a wing length of 2·3 is not uncommon and the smallest size recorded is 1·75 mm. However, in a series bred from *Hydrangea macrophylla* Ser., N.S.W., the smallest male has a wing length of 1·6 mm. and the largest female 2·3 mm.

2. Sasakawa has found the female terminalia of Japanese specimens to be identical with one of the Guam series.

3. The puparium in all cases is pale yellowish-brown.

4. I have compared the male genitalia of specimens from *Tylophora barbata* R.Br. and *Hydrangea macrophylla*, N.S.W., *Euonymus japonicus* Linn., Japan, *Passiflora foetida* L., Ceylon, and caught specimens from Guam. The general form of ninth sternite and the complex aedeagus (figs. 7a, b) agree closely; in my opinion, the minor differences noted cannot justify the establishment of separate species.

5. I previously thought that in the smallest specimens the bristle on the mid-tibia was lacking and that *atomella* could be differentiated from *styricicola* by this character. It is now found, however, that a short, slender bristle is always present; this cannot be detected in the holotype owing to slight damage to the legs, but is distinct in the topotypical paratype.

Sasakawa has hitherto treated *styricicola* as distinct from *atomella*, owing to lack of detailed information on Malloch's type and on the distribution of the species outside Japan. In view of the evidence cited above, it is now considered that *styricicola* must be synonymized with *atomella* and this synonymy is formally established herewith.

M. polyphyta Kleinschmidt, bred from leaf-mines on *Passiflora suberosa*, is clearly identical with *atomella* which has previously been bred from this host and this synonymy is also established herewith.

Food-plants recorded for the species are as follows:—

AUSTRALIA:

1. *Adults*

Tylophora barbata (Asclepiadaceae), Otford, South of Sydney, bred 30.i.1961; one ♂, one ♀, mines also found at Waterfall, N.S.W., 30.i.1961 (K.A.S.).

Hydrangea macrophylla (Saxifragaceae), Lisarow, N.S.W., Oct., 1958, 2 ♂, 4 ♀ (K. M. Moore), leaf-mines found at Botanical Gardens, Sydney, 23.i.1961 (K.A.S.).

Passiflora suberosa L. (Passifloraceae), Queensland, Kenmore, Feb., 1957 (Kleinschmidt, as *polyphyta* sp.n.).

Angophora intermedia DC (Myrtaceae), N.S.W., Lisarow, 17.x.1958 (K. M. Moore).

2. *Leaf-mines*

Marsdenia rostrata R.Br. (Asclepiadaceae), N.S.W., Otford, 29.i.1961 (K.A.S.).

Stephania japonica (Thunb.) Miers (Menispermaceae) N.S.W., Otford, 29.i.1961 (K.A.S.).

Celastrus subspicatus Hook. (Celastraceae), N.S.W., Windsor, 25.i.1961 (K.A.S.).

Barringtonia gracilis (Miers) Knuth (Lecythidaceae), N.T., Darwin, Howard Springs, 16.ii.1961 (K.A.S.).

Passiflora suberosa (fig. 9) (Passifloraceae), Qld., Brisbane, Botanical Gardens, 22.i.1961 (K.A.S.).

Doryphora sassafras Endl. (Monimiaceae), N.S.W., Clyde Mountain, 5.ii.1961 (K.A.S.).

JAPAN:

Actividia arguta Plaud. (Actinidiaceae.)

Celastrus orbiculatus Thunb. (Celastraceae.)

Euonymus japonica T. (Celastraceae.)

Fraxinus verecunda Koidz. (Oleaceae.)

Ilex pedunculosa Miq. (Aquifoliaceae.)

Marlea plantanifolia macrophylla Maki. (Alangiaceae.)

Pittosporum Tobira Ait. (Pittosporaceae.)

Styrax japonicum Sieb. et Zucc. (Styracaceae.)

Tylophora aristolochioides Miq. (Asclepiadaceae.)

MICRONESIA:

Morinda sp. (Rubiaceae.)

ORIENTAL REGION:

Barringtonia acutangula Gaertn. (Lecythidaceae), Bombay

B. asiatica Kunz, Bombay.

Bougainvillea spectabilis Willd (Nyctaginaceae), Bombay.

Eupatorium odoratum L. (Compositae), Ceylon.

Flacourtia sp. (Flacourtiaceae), Bengal.

Quisqualis indica Blanco (Combretaceae), Ceylon.

Passiflora spp., (Passifloraceae), Ceylon.

M. polyphaga Spencer, 1961, from Ceylon is not distinguishable from larger specimens of *atomella*, but the puparium is consistently dark black. This species was widespread in Ceylon and did not overlap there in choice of host-plant with *atomella*.

In leaf-mines found on *Smilax australis* A. Cunn. ex D.C. (Liliaceae) at Clyde Mountain, N.S.W., and also at Careel Bay, near Sydney, the puparium is also entirely black. It is believed that this represents a distinct species. Similar mines were found by the author on *Smilax indica* Burm. near Calcutta in January, 1960. (Spencer, 1961: 76).

Distribution: Qld., N.S.W., N.T., Japan, Guam, Philippines, Java, Flores, India, Ceylon.

Melanagromyza bowralensis sp.n.

Head (fig. 10): exceptionally broad, frons slightly wider than eye, only slightly projecting above eye in profile; two equal ors, the upper projecting upwards and outwards, the lower upwards and inwards; three (on one side four) strong, equal ori, all directed inwards; orbital setulae numerous, long, all proclinate, apart from one or two hairs, between ors; orbits broad, pronounced; ocellar triangle broad, apex extending to upper ori; lunule high, narrow, sunk below orbits, with central furrow; jowls one-sixth height of eye, cheeks forming only narrow ring below eye, not projecting at base of antennae; eye large, almost round, only slightly higher than broad, in female with sparse hairs at level of ors; antennae separated at base by distinct, narrow keel, third segment rounded, with short pubescence, arista long, appearing virtually bare.

Mesonotum: Two strong dc, second midway between level of supra and intra-alar, acr in eight rows, four rows extending behind first dc.

Wing: length in female 3·1 mm., costa extending strongly to vein m1 + 2, rm just beyond midpoint of discal cell, last segment of m4 two-thirds length of penultimate.

Colour: head entirely black, ocellar triangle and orbits only faintly shining, mesonotum black with faint coppery reflection, appearing largely matt from front, more shining from behind, abdomen shining coppery-greenish; wings clear, veins black, squamae white with brownish-orange borders, fringe white.

Holotype: ♀, N.S.W., Bowral, caught on waste ground, 30.i.1961 (K.A.S.), in author's collection.

This species is unusual in having entirely proclinate orbital setulae, which differentiates it from all recorded Australian species. In the area where it was caught there is much introduced European vegetation and it has been carefully compared with European species having the orbital setulae at least partially proclinate. In both *cirsii* (Rondani) and *dettmeri* Hg., 1933, the setulae are in two distinct rows, the inner row being proclinate, while the outer row near the eye margin is distinctly reclinate; in addition, in *cirsii* there are only two ori. In the true *aeneiventris* (Fall.) from *Urtica* the chaetotaxy of the head is similar but the squamae and fringe are black.

M. tripolii Spencer, 1957, which feeds exclusively in stems of the maritime *Aster tripolium* L., has entirely proclinate orbital setulae but they are significantly sparser. It thus seems reasonably certain that a new species is involved.

Melanagromyza cassiae sp.n.

Head: frons almost one-and-a-half times width of eye, not projecting above eye in profile; two ors, the upper distinctly stronger, two ori, the upper equal to lower ors and directed upwards, the lower weaker and directed inwards; orbital setulae reclinate; ocellar triangle with apex extending to lower ors, with trace of furrow continuing to margin of lunule; jowls narrow, eye large, almost round; third antennal segment rounded, with short pubescence, arista relatively long, little shorter than height of eye, appearing bare.

Mesonotum: two strong pairs of dc, acr ending midway between first and second dc.

Legs: mid-tibia with one strong postero-dorsal bristle.

Wing: length in male 1·9 mm; costa extending strongly to vein m1 + 2, rm slightly beyond midpoint of discal cell, last segment of m4 distinctly shorter than penultimate in ratio 13: 18.

Colour: entirely black, frons matt, ocellar triangle weakly shining; mesonotum largely shining but less so from front; wings clear, veins dark brown, squamae dark grey, fringe black.

Male genitalia: aedeagus highly distinctive (fig. 11a, b), black, asymmetric, with an unusual lateral process on the distiphallus.

Holotype ♂, N.S.W., Careel Bay, N. Sydney, caught on *Cassia bicapsularis* L., 3.ii.1961 (K.A.S.), in author's collection, one ♀ paratype, same data, presented to Australian Museum, Sydney.

It is accepted that this species is responsible for the incomplete epidermal leaf-mines found on the plant where the flies were taken. Similar mines were found on *Erythrina* sp. nearby, and it is believed that these are formed by the same species. Two females, caught on *Erythrina* sp., near Brisbane, where epidermal mines of an earlier generation were also present, are referred to the same species. Confirmation is, however, desirable from males bred from Erythrina. Séguy (1951) described *M. vigneae* from Madagascar which, apart from its primary host, *Vigna angivensis* Baker, was also recorded as a leaf-miner on *Cassia occidentalis* L. I have not been able to examine these specimens; however, I have recently examined the genitalia of specimens bred from *Vigna unguiculata* (L.) Walp. in Sénégal, West Africa, which have been identified as *vigneae* Séguy (Spencer, 1959), and can confirm that this species is distinct from *cassiae* and also from *atomella*.

This new species closely resembles *atomella* (Malloch). Apart from the very different genitalia the species can be distinguished by the arista, which is bare in *cassiae* and distinctly pubescent in *atomella*. The latter species, as far as I know, has never been recorded on Leguminosae.

Melanagromyza centrosematis de Meijere, 1940

Location of holotype: ZM.

This small, shining black species closely resembles *M. atomella* (Mall.), and *M. cassiae* Spencer; it has recently been discussed by Spencer (1961, 1961a). The distinguishing characters are the relatively deep jowls and the fine, virtually bare arista.

The species has a very distinctive aedeagus, which has been illustrated together with the ninth sternite, by Spencer (1961a). In view of its peculiar asymmetry a further drawing is shown in fig. 12a and also the characteristic spermal sac in fig. 12b.

The larva has been recorded feeding in the stem and roots of *Centrosema pubescens* Benth. and *Glycine soja*; it seems likely that it will also feed in other Leguminosae.

The single Australian specimen is from N.S.W., 10 m. west of Wilcannia, 22.xi.1949 (S.J.P.).

Distribution: N.S.W., Malaya, Formosa, Java, Tanganyika. New to Australia.

Melanagromyza conspicua Spencer, 1961

Location of holotype: AC.

This small black species resembles *atomella* (Mall.) but is readily distinguishable by the deeper jowls, which are one-sixth the vertical height of the eye, and the distinct pubescence on the third antennal segment in both sexes.

The species was described from two males from Singapore and Ceylon; the latter specimen was caught on *Tithonia diversifolia* A. Gray (Compositae). A series of two males and three females were caught on foliage of *Siegesbeckia orientalis L.* at Cabbage Tree Creek, Clyde Mountain, N.S.W., on 5.ii.1961, and a male and female were swept on damp vegetation at the foot of Mt. Coot-tha, Brisbane, on 22.i.1961.

The aedeagus of the species is distinctive, having a large, pale-brown sac-like structure covered with conspicuous sensory pores, similar to that occurring in *O. angustilunula* and *O. micra* described below; it was illustrated in the holotype by Spencer (1961, fig. 42).

The female has not hitherto been known; it agrees exactly with the male, apart from its larger size, having wing-length up to 2·4 mm. In the type specimens the frons does not project above the eye in profile; however, in some of the N.S.W. series the frons is distinctly raised above the eye in the area of the ori and the same applies to five specimens examined from New Guinea. It is unusual to find this degree of variation in the configuration of the frons, which has hitherto been found to be a reasonably constant character.

This species very closely resembles *M. provecta* de Meij, 1922, described from Java and since widely recorded in Africa (as *communis* Spencer). In *provecta* the genitalia are distinctive (Spencer, 1961b, fig. 1) and the arista is longer and more distinctly pubescent.

It now seems certain that the species feeds on a number of genera of the Compositae either as a leaf-miner or possibly in the flower-head.

Distribution.: Queensland: Brisbane; N.S.W.: Clyde Mountain; New Guinea, Formosa, Singapore, Ceylon. New to Australia.

Melanagromyza dianellae Kleinschmidt, 1960

Location of holotype: QM, Reg. No. T5808.

This is a small, shining black species, with wing-length up to 1·6 mm. and with white squamae and fringe. It is very similar to *M. paramonovi*, described below, but immediately distinguishable by the narrow jowls (fig. 13), which are one-tenth height of eye and the smaller size. The ninth sternite has the same conspicuously elongated hypandrial apodeme as in *paramonovi*, but is smaller, and the postgonites have a distinct group of minute sensory pores; the aedeagus (fig. 14) is also of similar type but the basal section is more regular, not distinctly asymmetric. The genitalia and also leaf-mines are figured by Kleinschmidt (1960: 12-13).

This species forms a clear group with *M. paramonovi* and a further species shortly to be described from New Guinea; the only other similar species are *M. galactoptera* Bezzi, 1926, from Rodrigues and *M. lustralis* Spencer, 1959, from the Cape Verde Islands.

The larva forms a silvery epidermal mine in the narrow leaves of *Dianella caerulea* Sims. I have also found mines referable to the same species on *Eustephus* at Mt. Coot-tha, Brisbane. The larva pupates in the leaf.

Distribution.: Queensland: Coolangatta, Brisbane; N.S.W.: Cobar, Lawson, Bronte, near Sydney.

Melanagromyza indigoferae Kleinschmidt, 1960

Location of holotype: QM, Reg. No. T5806.

Head: two ors, upper slightly stronger, two equal ori, the upper directed upwards, the lower incurved, orbital setulae sparse, but long; jowls narrow, rounded; third antennal segment with conspicuously long, whitish upcurved pubescence, arista bare, distinctly thickened at base.

Mesonotum: 2 dc, acr irregularly in three or four rows in front, not extending behind second dc.

Wing: length in male 1·3 mm., costa extending strongly to vein m1 + 2, rm at anterior third of discal cell, last and penultimate segments of m4 equal, costal segments 2, 3, 4, in ratio 22: 6: 5.

Legs: mid-tibia without differentiated postero-dorsal bristles.

Colour: entirely black, mesonotum only moderately shining, greyish-black, wings clear, veins dark, squamae grey, fringe black.

The genitalia have been figured by Kleinschmidt (1960: 10).

The type series was bred from leaf-mines in *Indigofera suffruticosa* Mill.; the species has also been bred from *Indigofera australis* Willd. (A. Dyce). The leaf-mine (fig. 15) is indiscriminately upper or lower surface (not epidermal), linear, whitish. The puparium is brilliantly shining black and is glued very firmly to the leaf, with the anterior spiracles projecting through the leaf-epidermis.

This is the smallest species of this genus known to me. It is readily distinguishable from *pisi* Kleinschmidt by the more greyish mesonotum, narrow jowls and more pubescent third antennal segment.

Distribution.: Queensland: Eight Mile Plains; N.S.W.: Clyde Mountain, Cabbage Tree Creek and Colo Vale.

Melanagromyza metallica (Thomson)

Agromyza metallica Thomson, 1869.

Melanagromyza metallica (Thomson), Spencer, 1959.

Location of holotype: Naturhistorika Riksmuseum, Stockholm.

This species appears to be common in Queensland, extending south to the Sydney area in N.S.W.

It is the commonest and most widespread of the shining green species, and although its biology has not yet been clarified, it is virtually certain that the larva feeds either in the stems or flower-heads of Compositae.

The species agrees almost completely with *albisquama* (Malloch), apart from the distinctive patch of hairs on the male eye; wing length is normally from 2·2 to 2·4 mm., but larger specimens have been confirmed in South Africa. The female specimens from Queensland have a wing length of up to 2·6 mm. The arista is always distinctly plumose. The aedeagus is distinctive, with conspicuous sensory pores on one of the distal processes, and has been illustrated by Spencer (in press, fig. 6b). The species has recently been discussed by Spencer (1959, 1961, 1961a, 1961b, 1961c, in press).

Distribution: Queensland, N.S.W., New Guinea, Micronesia, Indonesia, Philippines, Mauritius, Seychelles, South Africa, Congo, Cape Verde Islands. New to Australia.

Melanagromyza murrayae sp.n.

A minute black species with the following essential characters: jowls narrow, arista long, distinctly pubescent, mid-tibia without postero-dorsal bristle, wing length 1·5 mm., with costa extending strongly to m1 + 2, rm well beyond centre of discal cell, last and penultimate segments of m4 equal (fig. 16), squamae grey, fringe black. Puparium pale brown, with darker markings dorsally, spiracles as in *atomella* (Mall.).

Holotype ♀, Brisbane, Botanical Gardens, bred from epidermal leaf-mine in *Murraya paniculata* Jack (Rutaceae) 22.i.1961, adult emerged 6.ii.196 (K.A.S.), in author's collection.

This species is immediately distinguishable from *atomella* by the equal last and penultimate segments of vein m4 and from *alysicarpi* by the stronger costa, which continues distinctly to vein m1 + 2; it is distinguishable from the even smaller *indigoferae* by its more pubescent arista.

The only other species known to feed on the Rutaceae is *M. citri* Spencer, 1959, bred from *Citrus* sp. in Africa; in this species the costa extends only to vein r4 + 5.

Melanagromyza paramonovi sp.n.

Head (fig. 17): frons one-and-one-third times width of eye, not projecting above eye in profile, two strong, equal ors, two weaker ori, lower ori directed predominantly inwards, upper ori and ors predominantly upwards; orbital setulae reclinate; ocellar triangle with apex at level of lower ors, lunule in form of semicircle; jowls relatively broad, quarter height of eye, cheeks forming narrow ring below eye; third antennal segment small, round, arista fine, bare, as in *M. verdescens* (fig. 3b).

Mesonotum: chaetotaxy normal.

Wing: length in male 1·9 mm., costa extending to vein m1 + 2, rm beyond midpoint of discal cell, last and penultimate segments of m4 equal.

Colour: head black, frons matt, ocellar triangle and orbits weakly shining; mesonotum and abdomen shining black, wing conspicuously pale; veins pale brown; squamae and fringe white.

Male genitalia: aedeagus (fig. 18a) with two long tubules distally, basal section asymmetric, reduced on one side; ninth sternite (fig. 18b) with conspicuously elongated hypandrial apodeme, postgonites with two distinct sensory pores distally; spermal sac as in fig. 18c.

Holotype: ♂, N.S.W., 10 m. W. Wilcannia, 22.xi.1949; six paratypes: one ♂, same data as holotype, one ♂, 50 m. W. Cobar, one ♀, 30 m. W. Cobar, 24.xi.1949, 3 ♀, 40 m. N. Broken Hill, 19.xi.1949 (all S.J.P.). Holotype, four paratypes, C.S.I.R.O., Canberra, two paratypes in author's collection.

This species is closely related to *M. dianellae* Kleinschmidt, but is readily distinguishable by the deeper jowls and differing genitalia. The closest known relative outside Australia is *M. galactoptera* Bezzi, 1926, from Rodrigues; this is somewhat larger, the jowls are narrower and the arista is conspicuously long.

The species is named in honour of S. J. Paramonov; 16 specimens he collected in western N.S.W. in November, 1949, included five species described as new in this paper.

Melanagromyza phaseoli (Tryon)

Oscinis phaseoli Tryon, 1895.

Agromyza phaseoli Coquillet, 1899.

Agromyza destructor Malloch, 1916.

Melanagromyza phaseoli (Tryon), Spencer, 1959: 283-4.

Location of holotype: believed lost.

This species is well known in Australia as the Bean Fly; it was until recently credited to Coquillet, but Tryon's original description must be accepted as valid.

The small black fly is readily distinguishable from all others in the genus by the greatly elongated, brilliantly shining ocellar triangle.

The larva is a serious pest on cultivated leguminous crops and has been recorded on *Phaseolus, Vigna, Soja, Cajanus, Dolichos, Crotalaria.* I found the species to be common on *Phaseolus lathyroides L.* near Brisbane, at the end of January, 1961.

Oviposition takes place in a young upper leaf and the larva initially forms a narrow linear leaf-mine running towards the petiole and stem. The mine continues down the stem, either beneath the epidermis or deeper inside the stem, where pupation takes place. At the point of pupation the stem turns brown and frequently breaks open. Young plants infested invariably die. The biology of the species has been dealt with in some detail by Otanes y Quesales (1918), van der Goot (1930) and Hassan (1947).

The genitalia have not, as far as I know, previously been examined. The ninth sternite has a short, rounded hypandrial apodeme similar to that in *sojae* (Zehntner); the aedeagus (fig. 19) appears to resemble most closely that of *albisquama* (Malloch).

Distribution: Queensland, N.S.W., Micronesia, Formosa, Indonesia, Philippines, Malaya, India, Africa, Egypt.

Melanagromyza piliseta (Malloch)

Agromyza piliseta Malloch, 1914.

Melanagromyza piliseta (Malloch), Hennig, 1941; Spencer, 1961.

Location of holotype: HNM.

One female, Queensland, Townsville (F. H. Taylor), no date. This is a large green species, with wing length of 2·7 mm.; the arista is conspicuously plumose and in both male and female the eye has a distinct patch of white hairs; the ocellar triangle is conspicuously large and shining.

The species is widespread in the Oriental region, and its occurrence in Queensland is not surprising.

Distribution: Queensland, Formosa, Indonesia, Ceylon. New to Australia.

Melanagromyza pisi Kleinschmidt, 1960

Location of holotype: QM.

Very similar to *indigoferae* Kleinschmidt, so that differences only need be noted:

Jowls conspicuously broad, one-sixth vertical height of eye, third antennal segment with only slight pubescence; acrostichals extending in several rows to level of first dc; wing length 1·6 mm.; mesonotum shining black.

I have been able to examine two specimens, one a paratype, and there appears to be a distinct narrow keel separating the antennae, suggesting that the species might belong to the genus Ophiomyia. However, the genitalia confirm that the species is correctly placed in Melanagromyza.

The larva forms an upper surface, whitish leaf-mine on *Pisum sativum* L., pupating in the mine. Male genitalia and leaf-mines have been illustrated by Kleinschmidt (1960: 5).

Distribution.: Queensland: Toowong.

Melanagromyza placida sp.n.

Agreeing closely with *M. cassiae* Spencer, with the following points of difference: four ors directed upwards, the two lower distinctly shorter, two incurved ori, orbital setulae rather long; wing length in male 2·2 mm., venation distinctive (fig. 20), rm three-quarters distance from base of discal cell; aedeagus (fig. 21) distinctive, distiphallus a large elongated, bowl-shaped structure, pale-brown, basiphallus forming complete ring, black, strongly chitinized above, broader, paler below, phallophore elongated, spermal sac large.

Holotype ♂, Queensland, Lake Placid, near Cairns, 24.v.1958 (D.K.M.), Australian Museum, Sydney.

This species agrees with *cassiae* in having narrow jowls, bare arista and a distinct bristle on the mid-tibia, but is slightly larger and immediately distinguishable by the different position of cross-vein rm and the larger number of orbital bristles.

Melanagromyza seneciophila sp.n.

Head: frons broad, in male one-and-a-half times, in female twice, width of eye, not projecting above eye in profile; two equal ors directed upwards, orbital setulae reclinate apart from single proclinate hair in front; ocellar triangle large but ill-defined at apex, lunule slightly higher than semicircle, almost flat at upper margin; jowls well-developed, one sixth vertical height of eye; cheeks linear; antennae approximate, third segment small, slightly longer than broad, rounded above, arista only minutely pubescent, appearing bare.

Mesonotum: two strong dc, second mid-way between supra- and intra- alar; acr coarse, in eight rows, extending in some four rows to first dc.

Wing (fig. 22): length in male 2·5, in female 3 mm., unusually narrow; costa extending strongly to vein m1 + 2, rm near centre of discal cell, last segment of m4 about half length of penultimate.

Colour: Ocellar triangle weakly shining, head otherwise matt black; mesonotum and abdomen predominantly shining black but with faint greenish or coppery reflections, wing conspicuously clear, veins unusually dark, black, squamae pale, whitish-grey, margins brown, fringe white.

Puparium: dirty greyish-brown with distinctive bands of scars and minute black tubercles around segment boundaries and also additional scars dorsally between these bands (fig. 23). Each posterior spiracular process an ellipse of 10-12 indistinct, heavily chitinized buds surrounding strong black truncate horn, the two processes separated by their own diameter.

Male genitalia (fig. 24): aedeagus as illustrated, ninth sternite with strong, characteristically elongated hypandrial apodeme.

Holotype ♂, N.S.W.: Waterfall, south of Sydney, larva found 29.i.1961, in stem of *Senecio vagus* F. Muell, emerged 20.ii.1961, in author's collection; ♀ paratype, same locality, puparium found 29.i.1961, emerged 9.ii.1961 (both K.A.S.), presented to Australian Museum, Sydney.

The unusually narrow wings, black veins and short last segment of m4 make this a distinctive species; the greenish tinge of mesonotum and abdomen might be overlooked and the species confused with *alternata*, but the species can immediately be distinguished by differences in the wing. The exceptionally long hypandrial apodeme of the ninth sternite is also similar to that in *alternata*. Other species feeding as internal stem-borers in *Senecio* spp.—*seneciocaulis* Spencer (1960) in Africa and *dettmeri* Hering (1933) in Europe have the eye in the male conspicuously haired.

Melanagromyza sojae (Zehntner)

Agromyza sojae Zehntner, 1900.

Agromyza prolifica Malloch, 1914.

Melanagromyza sojae (Zehntner), de Meijere, 1922; Spencer 1961, in press.

Location of holotype: ZM.

One male, bred from stem of *Swainsona galegifolia* (And.) R.Br. (Smooth Darling Pea) N.S.W., Groman, 29.xii.1960 (T. V. Bourke).

This small species is immediately recognizable by the shining black mesonotum and green abdomen; the squamal fringe is white.

The larva feeds as an internal stem-borer in Leguminosae, and recorded hosts include *Glycine*, *Cajanus* and *Phaseolus*. The species is frequently found on cultivated crops, but damage caused is invariably slight. The biology has been discussed in some detail by van der Goot (1930: 54-68).

Distribution: N.S.W., Formosa, Java, Flores, Sumbawa, India, Egypt. New to Australia.

Melanagromyza specifica sp.n.

This species closely resembles *metallica* (Thomson), and it is only necessary to give here the points of difference: ocellar triangle and orbits more distinctly shining; arista long but virtually bare; jowls somewhat deeper; mesonotum dull blackish-green, not predominantly shining green; squamae and fringe entirely white, borders of squamae not contrasting orange-brown, wing length in male 1·9-2 mm., aedeagus distinctive, as illustrated (fig. 25a), without sensory pores on lower distal process, ninth sternite with conspicuously elongated pre-gonites (fig. 25b).

Holotype ♂, Queensland: near Brisbane, swept on damp vegetation by gravel pit below Mt. Coot-tha, 22.i.1961 (K.A.S.), in author's collection; one ♂ paratype, N.S.W., 40 m. north of Broken Hill, 19.xi.1949 (S.J.P.), C.S.I.R.O., Canberra. One ♀, same data as paratype, is substantially larger, with wing length 2·6 mm.; it agrees otherwise closely with this species, but, in view of the larger size, it is not placed as a paratype.

This species has the pilose eyes in common with *metallica*, but is immediately distinguishable by the virtually bare arista, which appears intermediate between the long, pubescent arista of *metallica* and the short bare arista of *verdescens*. The generally darker colouration is also distinctive.

The aedeagus is somewhat similar to that of *M. inulivora* Spencer (1961c, fig. 8) from South Africa, but it seems preferable at this stage to treat the species as distinct.

Melanagromyza trispina (Malloch), comb. nov.

Agromyza (*Melanagromyza*) *trispina* Malloch, 1927.

Location of holotype : IHTM.

This species is represented only by the unique, male holotype from Merredin, Western Australia.

I have examined the holotype, which is in perfect condition. The species is immediately recognizable from all others so far known in Australia by the presence of three pairs of dc. Other essential characters of the species are: mesonotum and abdomen entirely black, squamae and fringe white, orbits well-defined, ocellar triangle large but ill-defined at apex, body robust, wing length approximately 2·7 mm.

Melanagromyza verdescens sp.n.

Head: frons just wider than eye, not projecting above eye in profile, two ors, upper slightly stronger, two ori, upper equal to lower ors, lower distinctly weaker, orbital setulae upright in front, reclinate behind, extending to upper ors; ocellar triangle conspicuous, narrow but elongated, apex beyond lower ors; lunule narrow, higher than semicircle, upper margin midway between ori, jowls deepest in centre below eye, vibrissa equal to lower ori, eye circular below, more oval above, bare in male; third antennal segment small, rounded, arista short, fine, bare, thickened at base (fig. 3b).

Mesonotum: two pairs of dc, second at level of supra-alar, acr in six rows in front, scattered hairs extending behind first dc.

Wing: length in male 1·9 mm., costa extending to m1 + 2, rm at mid-point of discal cell, last segment of m4 in ratio 14: 19 with penultimate.

Colour: ocellar triangle and orbits distinctly shining, head otherwise matt black, mesonotum shining blackish with distinct greenish tinge, abdomen more greenish; wings clear, veins dark-brown, squamae and fringe white, halteres black.

Male genitalia: aedeagus as illustrated (fig. 26a), basal section with strongly chitinized ring distally, largely membranous adjoining aedeagal apodeme, spermal sac (fig. 26b) conspicuously large.

Holotype: ♂, N.S.W., 10 m. west of Wilcannia, 22.xi.1949; two ♂ paratypes, one, same data, one, 12 m. south of Mt Pack Saddle, 18.xi.1949 (all S.J.P.); holotype and one paratype C.S.I.R.O., Canberra, one paratype in author's collection.

This species is readily distinguishable from *albisquama* (Mall.) and *metallica* (Th.) by the high narrow lunule, deeper jowls and the fine, bare arista. The form of arista is that found in the majority of *Ophiomyia* spp., but in other characters, including the aedeagus, this species is a typical *Melanagromyza.* The third antennal segment and distinctly more pubescent arista of *M. albisquama* is shown in fig. 3a.

Melanagromyza wikstroemiae Kleinschmidt, 1960

Location of holotype: QM, Reg. No. T 5800.

Head: frons broad, almost twice width of eye, not projecting above eye in profile; two strong, equal ors directed upwards, two equal, weaker ori, the upper directed upwards, the lower inwards; orbital setulae reclinate, from lower ori to upper ors; ocellar triangle not greatly differentiated, lunule low, normal; jowls well-developed, one-seventh vertical height of eye, rounded, cheeks linear, eye oval, upright, not pilose; antennae with bases slightly separated, third segment small, rounded, arista fine, bare, thickened at base.

Mesonotum: two pairs of strong dc, second at level of supra-alar, acr relatively long, in six to eight rows, not extending to level of first dc.

Legs: Mid-tibiae without differentiated postero-dorsal bristle.

Wing: Length in male and female 2·1 mm., costa extending strongly to vein m1 + 2, rm just beyond mid-point of discal cell, last segment of m4 three quarters length of penultimate.

Colour: frons matt black, ocellar triangle and orbits scarcely shining, jowls more brownish; mesonotum matt black, scarcely shining even from behind, abdomen largely matt black, though slightly more shining than mesonotum; wings clear, veins black, squamae grey, fringe deep black.

Male genitalia: (fig. 27) ninth sternite with exceptionally broad and elongated hypandrial apodeme, aedeagus ending in characteristic distal tubule. The genitalia are also illustrated by Kleinschmidt (1960: 2).

Puparium: entirely matt black, segmentation indistinct, anterior spiracles on two long arms, posterior spiracles minute, each with three buds on common, low spherical protuberance.

Leaf-mine (fig. 28): irregular, considerably widening, upper surface linear mine, frons widely spaced in distinct lumps, puparium remains in mine, with anterior spiracles projecting through leaf epidermis.

The species is readily distinguishable by the matt mesonotum and absence of a bristle on the mid-tibia. The leaf-mines are abundant locally but the species is heavily parasitized by a Chalcid and also by a Braconid.

The type series was bred from leaf-mines on *Wikstroemia indica* Endl. I have also found the species to be abundant on *Pimelea ligustrina* Labill.

Distribution: Queensland: Kenmore; N.S.W.: Otford, Kangaroo Valley.

I have examined a female from Otford, 26.i.1959 (D.K.M.), in the Australian Museum Sydney, which is close to *M. wikstroemiae* but appears to represent a distinct species; there is one strong bristle on the mid-tibia and the wing length is greater, 2·4 mm; more material, however, is necessary before this can be satisfactorily described as a new species.

Melanagromyza sp. (N.S.W.)

A single female from N.S.W., Upper Hunter, Tubrabucca to Moonan, c. 2,000 ft., 19.x.1961 (D.K.M.), in Australian Museum, Sydney, appears to represent a new species.

The specimen is in somewhat imperfect condition, and it seems preferable not to describe a further species until additional material is available. The essential characteristics of the species are as follows:—

Frons one-and-a-half times width of eye, slightly projecting above eye in profile, two ors, two ori, ocellar triangle conspicuous, rather strongly shining, jowls deep, one-fifth vertical height of eye, mid-tibia possibly with single postero-dorsal bristle, wing length 2·4 mm., venation distinctive, with last and penultimate segments of vein m4 equal, first cross-vein at distal third of discal cell, slanting slightly forwards so that, if extended, it would meet lower end of second cross-vein, an entirely black species, mesonotum and abdomen largely shining, squamae grey, fringe black.

Genus **Ophiomyia** Braschnikov

Ophiomyia Braschnikov, 1897, Ann. Inst. Agron. Moscow 3: 40.

Type species *Agromyza maura* Meigen, Europe.

This relatively small genus is distributed fairly equally throughout the world. The males of most, but not all, species have a distinctive vibrissal fascicule (fig. 37); again in most, but not all, species there is a conspicuously bulbous carina dividing the base of the antennae. In South Africa there is a well-developed group of diminutive species with white squamae and fringe (Spencer, 1960), which is represented in Australia by *O. augustilunula* and *micra*, described below.

The feeding habit of the larva is greatly varied. Many are external stem-miners (*O. atralis*), others leaf-miners (*O. goodeniae*) or seed-eaters (*O. lantanae*).

O. cornuta (de Meijere) 1910, a leaf-miner on *Scaevola* spp., is widely distributed in the western Pacific and can be expected to occur in coastal areas of Queensland; it is included in the key to Australian species given below.

1. Squamal fringe black 2
   Squamal fringe pale, whitish 3
2. Facial keel broad and bulbous .... *lantanae* (Froggatt)
   Facial keel narrow, scarcely projecting .... *solanicola* sp.n.
3. Vibrissal angle acute, at most 45 degrees .... *goodeniae* sp.n.
   Vibrissal angle 60 degrees to 90 degrees 4
4. Mesonotum distinctly grey, male without vibrissal horn .... *atralis* (Spencer)
   Mesonotum shining black; male with vibrissal horn 5
5. Lunule conspicuously high and narrow, orbital setulae numerous, directed upwards and outwards .... *angustilunula* sp.n.
   Lunule in form of semicircle; orbital setulae sparse, reclinate 6
6. Last segment of m4 slightly longer than penultimate; wing length 1·6 mm. .... *micra* sp.n.
   Last segment of m4 shorter than penultimate ratio: 12: 17, larger species, wing length 1·9 mm. .... *cornuta* (de Meijere)

Ophiomyia angustilunula sp.n.

Head (fig. 29): frons narrow, scarcely equal to width of eye, not projecting above eye in profile, two ors and two ori (broken, detectable only from basal pits); orbital setulae conspicuously long and numerous, directed upwards and outwards; jowls one-eighth height of eye, deepest in front, cheeks forming broad ring below eye; male with long curving vibrissal horn, characteristically broadening at end, ocellar triangle broad but relatively short; lunule high and narrow, as found in *Poëmyza* spp.; antennae separated by very fine keel which only slightly widens below, third segment small, round, arista short, fine.

Mesonotum: two dc, second at level of supra-alar; acr coarse, in 6 to 8 rows ending mid-way between second and first dc.

Wing (fig. 30): length in male 1·75 mm.; costa extending to vein m1 + 2, rm conspicuously oblique, only own length removed from mm., last and penultimate segments of m4 equal.

Colour: ocellar triangle and orbits distinctly shining, remainder of head matt black, apart from pale brownish vibrissal horn; mesonotum and abdomen shining black; legs entirely black; wing conspicuously whitish, veins pale brown; squamae and fringe white, halteres black.

Male genitalia: aedeagus (fig. 31a) terminating in distinct dark brown sac covered with minute sensory pores, median section long with distinctly chitinized side arms; spermal sac very large (fig. 31b).

Holotype: ♂, N.S.W., 40 m. east of Wilcannia, 23.xi.1949 (S.J.P.), C.S.I.R.O., Canberra.

Ophiomyia atralis (Spencer)

Melanagromyza atralis Spencer, 1961.

Ophiomyia atralis (Spencer), in press.

Location of holotype: DEI.

This species was described as a *Melanagromyza* from caught specimens from Flores (Spencer, 1961: 69), but examination of a longer series from Micronesia showed the species to belong to the genus Ophiomyia.

Stem-mines found on *Vernonia cinerea* L. near Calcutta airport on 20.i.1961, produced flies 10 days later clearly referable to this species. Identical mines had been found at Bangkok on 16.i.1960, and were illustrated (Spencer, 1961: fig. 40), but no adults were obtained.

Further fresh mines containing puparia were found at the Botanical Gardens, Darwin, on 16.ii.1961, but again, unfortunately, no adults were obtained.

However, these mines and puparia are identical with those from Calcutta and Bangkok, and the identity of the species is not in doubt.

I had previously suggested (Spencer, 1961c) that specimens bred from stems and roots of *Striga hermonthica* Benth. in Kenya were referable to this species; I am now satisfied that these represent a distinct species, which will be described shortly.

The following are the essential characters of *atralis*: frons narrow, not wider than the eye in profile viewed from above; jowls narrow, but distinctly projecting in front, male without vibrissal horn; facial keel narrow and scarcely widening between antennae; mesonotum somewhat shining but distinctly grey; squamae and fringe white; first cross-vein at or slightly beyond midpoint of discal cell, last and penultimate segments of vein m4 approximately equal; wing length in male and female 1·9 mm.

Distribution: Darwin, N.T.; Calcutta, Bangkok, Flores, Micronesia. New to Australia.

Ophiomyia goodeniae sp.n.

Head (fig. 32): largely collapsed in only available specimen and detailed description not possible; two ors, the upper distinctly stronger; orbital setulae slight, sparse, reclinate, jowls narrow, greatly projecting in front, forming angle of 30 degrees; vibrissa in female strong, equal to upper ors; antennae divided by broad facial keel, bulbous below base of antennae but without centre furrow, arista relatively long.

Mesonotum: very similar to *O. solanicola* described below but second dc distinctly behind level of supra-alar.

Wing: length in female 1·4 mm.; costa extending strongly to vein m1 + 2; rm three-quarters distance from base of discal cell, conspicuously slanting; last segment of m4 in ratio 15: 19, with penultimate, virtually identical to *solanicola* (fig. 38).

Legs: mid-tibiae apparently without differentiated postero-dorsal bristle.

Colour: head entirely black, ocellar triangle brilliantly shining, orbits less so, mesonotum and abdomen shining black; squamae and fringe white.

Leaf-mine (fig. 33): a long, winding, white, upper surface channel, initially conspicuously narrow, frass deposited irregularly in black grains and strips, pupation in leaf.

Puparium: 2·2 x ·85 mm.; colour pale greyish-yellow, with distinct darker bands of tubercles at borders of segments, posterior spiracles two minute horizontal projections bearing apparently 3 buds, above a conspicuous darker brown anal projection.

Holotype: ♀, N.S.W., Waterfall, National Park, south of Sydney, emerged 1.ii.1961, from leaf-mine in *Goodenia ovata* Sm. found 29.i.1961 (K.A.S.), in author's collection.

The species is readily distinguishable from others with pale squamae by the acute angle formed by the conspicuously projecting jowls.

Ophiomyia lantanae (Froggatt)

Agromyza lantanae Froggatt, 1919.

Ophiomyia lantanae (Froggatt), de Meijere, 1925: 253.

Location of holotype: believed lost.

This species occurs widely with its food-plant, *Lantana camara* L., and is known in Australia from Queensland and northern N.S.W. The distribution in Africa and Asia has been discussed by Spencer (1959: 298 and 1961: 80).

It is a species typical of the genus, with a broad bulbous keel separating the antennae, a long vibrissal horn in the male and black squamae and fringe.

The aedeagus of a male from Brisbane is shown in fig. 34a; the basiphallus has the long side-arms characteristic of many species in the genus; the spermal sac is shown in fig. 34b.

The larva feeds in the receptacle of the flower-head and also in the fleshy part of the fruit surrounding individual seeds, but my own observations suggest that the hard seed itself is not normally damaged. This was also the view of Subramiam (1934), who has studied this species in India. The species has been widely introduced to assist in the control of lantana, but, in view of the actual feeding habit of the larva, it seems to me doubtful whether such measures are of much practical value.

Distribution: Queensland, N.S.W., India, Singapore, Ceylon, Kenya, Central America, Venezuela, Mexico.

Ophiomyia micra sp.n.

Closely resembling *angustilunula*, so that only points of difference need be noted.

Head: ocellar triangle slightly narrower and more elongated; orbital setulae short, sparse, lunule broader, lower, in form of semicircle; jowls extending more conspicuously in front, vibrissal horn longer, more distinctly bending.

Wing (fig. 35): length in male 1·6 mm., rm at mid-point of discal cell, last segment of m4 longer than penultimate in ratio 16: 13.

Colour: wing less conspicuously white, vibrissal horn black but becoming paler distally, otherwise identical to *angustilunula*.

Male genitalia: distiphallus (fig. 36a) paler, sensory pores larger, less numerous, median section short, at most half length of *angustilunula*, spermal sac (fig. 36b).

Holotype ♀, N.S.W., 40 m. east of Wilcannia, 23.xi.1949 (S.J.P.), C.S.I.R.O., Canberra.

Ophiomyia solanicola sp.n.

Head (fig. 37): frons relatively narrow, equal to width of eye, not projecting above eye in profile; two equal ors, two equal ori, only slightly weaker; ors directed upwards, ori more inwards; orbital setulae reclinate, short, sparse; ocellar triangle not greatly elongated, apex slightly below upper ors; orbits narrow but well-defined; jowls narrow, one-tenth vertical height of eye, distinctly projecting in front, forming angle of 80 degrees; male with vibrissal horn, characteristically curving at end; eye large, oval, upright; antennae separated at base by narrow facial keel, which slightly widens below and is distinctly indented, third antennal segment small, round, with distinct pubescence, arista relatively long, equal to width of eye viewed in profile.

Mesonotum: two strong dc, second at level of supra-alar, two-thirds length of first, acr thick in 8-10 rows in front, a few hairs only extending to level of first dc.

Wing (fig. 38): length in male 1·9, in female 2·2 mm.; costa extending strongly to vein m1 + 2, rm conspicuously near mm., four-fifths distance from base of discal cell, last and penultimate segments of m4 about equal.

Legs: mid-tibia with one small differentiated postero-dorsal bristle.

Colour: an all-black species; frons matt, sooty, ocellar triangle and orbits weakly shining; mesonotum largely shining, slightly matt viewed from front, abdomen shining; squamae and fringe black.

Male genitalia: aedeagus typical of the genus (fig. 39a), spermal sac large but conspicuously narrow (fig. 39b).

Puparium: 2·5 x 1·2 mm.; colour mainly brownish yellow but black along centre dorsally, anterior spiracles two long vertical projections slightly knob-like distally; posterior spiracles two short black, horizontal projections arising from corners of a common protuberance, each bearing three buds.

Leaf-mine (fig. 40): a long, winding, whitish, upper surface linear mine, sometimes following leaf-margin but also in centre of leaf, frass in an irregular line along centre of channel; puparium remains in mine with anterior spiracles projecting through epidermis of leaf.

Holotype: ♂, N.S.W., Clyde Mountain, emerged 13.ii.1961 from leaf-mines found Feb. 5, on *Solanum prinophyllum* Dunal (K.A.S.), two ♀ paratypes, one, same data, in author's collection, one presented to Australian Museum, Sydney.

This species is readily distinguishable from *lantanae* (Froggatt) by the narrower facial keel and from *goodeniae* Spencer by the black squamal fringe; it resembles a leaf-miner on Solanum from Madagascar being described by the author shortly, but the latter has whitish squamae with a pale, ochrous fringe and in the male the vibrissal horn is longer.

Genus **Cerodontha** Rondani

Cerodontha Rondani, 1861, Dipt. Hal. Prod: 4-10.

Type species: *Chlorops denticornis* Panzer, Europe.

This small genus of 20 described species is represented in Australia by three species.

The genus is represented throughout the world and, as far as is known, the larvae are exclusively leaf-miners on Gramineae.

The biology of the Australian species has not yet been established.

Key to Australian Cerodontha species

1. Mesonotum uniformly matt blackish-grey .... *australis* Malloch
   Mesonotum at least partially shining black 2
2. Mesonotum uniformly shining black .... *robusta* Malloch
   Mesonotum yellow with three shining black bands .... *vittigera* Malloch

Cerodontha australis Malloch, 1925

Location of holotype: IHTM.

The distinctive features of this species are as follows:—

Head: one ors, near centre of head between verticals and lower ori; two ori; orbital setulae short, sparse, not above upper ori; frons greatly projecting above eye in profile, jowls deep; third antennal segment elongated, with short spine on upper corner (fig. 41a).

Mesonotum: 3 + 1 dc; normally one or two pairs of acr present between third and fourth dc.

Wing: length in male 2·2-2·6 mm., in female 2·4-2·7 mm.

Colour: head predominantly yellow, orbits paler than frons which is frequently more brownish; first and second antennal segments yellow, third normally black but often paler, yellowish, particularly on inside; mesonotum greyish-black, scutellum similar, without any trace of yellow, mesopleura normally blackish-grey with very narrow yellowish area in upper margin but in some species more extensively yellow, abdomen blackish but tergites sometimes with yellow borders.

Legs: coxae and femora bright yellow but in hind and mid-legs sometimes distinctively darker, more brownish; tibiae and tarsi brown.

Male genitalia: distal section of aedeagus (fig. 42a) curved, long, rather pale, spermal sac as in fig. 42b.

This species closely resembles the Palaearctic species, *C. denticornis* (Pz.) but is distinguishable from it by the presence of at least sparse acrostichals, the uniformly dark scutellum even in the palest specimens and the paler third antennal segment. In *denticornis* the aedeagus is more strongly chitinized, the mesophallus is stouter, while the distal tubules are more conspicuously curved and longer (Spencer, 1961b: fig. 13).

Distribution: New South Wales: Blue Mountains, National Park, Bowral.

I have also examined six specimens of the species occurring widely in New Zealand and identified as *denticornis* (Harrison 1959: 309). I am satisfied that the species is not *denticornis* and it appears indistinguishable from *australis*. However, the male genitalia clearly suggest that it is a distinct species; the mesophallus is substantially broader and shorter even than in *denticornis*, and the distal tubules are very much shorter and almost straight.

Cerodontha robusta Malloch, 1925

Location of holotype: IHTM.

Head: frons broad, projecting above eye in profile, two ors, three ori, orbital setulae relatively long, cheeks forming broad ring below; jowls deep; third antennal segment with distinctive, short, upcurved spike at upper corner (fig. 41b); frons conspicuously high and narrow.

Mesonotum: 3 + 1 dc, acr in four irregular rows extending with scattered hairs to first dc.

Wing: length in male 2·4 mm., in female 2·7-3·2 mm.

Colour: frons basically yellow but darkened by microscopic hairs and appearing brownish; orbits, jowls, face yellow; antennae yellow but third segment variably darker on upper corner, spine black; mesonotum shining black, yellow patches at hind corners, scutellum black with trace of yellow in centre; pleurae variably yellowish; legs: coxae and femora yellow, tibiae nd tarsi brown, abdomen black, tergites with yellow borders.

The distinctive antennae and general coloration make this species readily distinguishable from all others known in the genus.

Distribution.—New South Wales: Sydney, Katoomba, Glen Davis, Mount Wilson.

Cerodontha vittigera Malloch, 1927

Location of holotype: IHTM.

Head: frons distinctly projecting above eye in profile; two ors, five ori, orbital setulae numerous, incurved, third antennal segment rounded below, curving up to prominent angle at upper corner, concave above.

Mesonotum: 3 + 1 dc, acr irregularly in four rows, a few hairs extending to midway between first and second dc.

Wing: length in male 3·2 mm.

Colour: head entirely yellow, frons slightly darkened in centre by microscopic hairs; third antennal segment darker at upper angle; mesonotum yellow in centre but with three brilliantly shining black bands; the two outer bands extend from shortly before the front of the mesonotum to the scutellum, filling the area between the line of the dorso-centrals on one side and a line joining the pre-sutural and post-alar on the other; the centre band runs along the entire length of the mesonotum in the holotype, but only to the level of the second dc in a second specimen examined; scutellum yellow in centre with a shining black area each side in the holotype. entirely black in the second specimen. Mesopleura largely black, yellow on upper margin, humerus and notopleural area yellow; sterno-pleura black below, yellow in upper quarter; abdomen black, tergites yellow laterally.

This is a distinctive species with conspicuously contrasting coloration. The variation in the colour of the scutellum of the two specimens noted above may possibly be of specific significance, but additional material is required before this can be confirmed.

Distribution: Western Australia, New South Wales, Mount Wilson.

Genus Phytobia Lioy

Phytobia Lioy, 1864, Atti Ist. Veneto (3), 9: 1313.

Type species *Agromyza errans* Meigen, Europe.

Frick (1952: 387) revived Lioy's name, which Hendel had ignored. Hendel (1936) divided the genus into eight well-defined sub-genera, five of which are represented in Australia. Nowakowski (1962) is again revising the genus and is proposing to split it into a number of distinct genera. In this paper I am following Frick.

The genus is represented throughout the world, being most strongly developed in the Holarctic region and the largest single genus in North America with 52 described species. In South America there is a striking proliferation of the sub-genus *Calycomyza*.

Key to Australian Phytobia species

1. Halteres black .... (*Amauromyza*) *caliginosa* sp.n.
   Halteres pale, white or yellow 2
2. Lunule distinctly higher than semicircle 3
   Lunule approximately in form of semicircle 4
3. Frons black .... (*Dizygomyza*) *poemyzina* sp.n.
   Frons yellow .... (*Icteromyza*) *triplicata* sp.n.
4. 3 + 0 dorso-central bristles .... (*Calycomyza*) *humeralis* (P. C. Roser)
   3 + 1 dorso-centrals .... (*Praspedomyza*) 5
5. Frons black .... *incerta* sp.n.
   Frons pale, yellowish 6
6. Third antennal segment entirely black .... *pittosporophylli* Hering
   Third antennal segment largely yellow .... *pittosporocaulis* Hering

Phytobia (Amauromyza) caliginosa sp.n.

Head: orbits pronounced, distinctly projecting above eye anteriorly (eye sunk, proportions with frons not detectable), two ors, the upper somewhat stronger; two ori, the upper equal to lower ors, the lower substantially weaker, orbital setulae in single row, long; jowls angular, deeply extended at rear; third antennal segment small, rounded, arista relatively short, distinctly thickened in lower third, without distinct pubescence.

Mesonotum: 3 + 1 dc, first and second strong, third and fourth equal, slight, half length of second, equidistant each side of suture; acr in four rows in front, a few scattered hairs extending to midway between first and second dc, inner post-alar slightly longer than third dc.

Wing (fig. 43): length in female 1·9 mm., costa extending strongly to vein m1 + 2, rm at midpoint of small discal cell, last segment of m4 twice length of penultimate, costal segments 2, 3, 4 in ratio 32: 12: 8.

Colour: frons dark brown, orbits slightly paler, antennae black, mesonotum matt black, with tendency to grey, abdomen slightly more shining, legs entirely black, wings clear, veins black, squamae grey, fringe black, halteres blackish-brown.

Holotype ♀, N.S.W., Blue Mountains, Springwood, Sassafras Gully, 17.xi.1956 (D.K.M.), Australian Museum, Sydney.

Only a single species of this sub-genus is known from the Oriental region (Formosa); this is, however, readily distinguishable from the Australian species by having only three dorsocentrals, by its more shining black coloration and differing venation.

Phytobia (Calycomyza) humeralis (v.Ros.)

Agromyza humeralis v.Roser, 1840.

Calycomyza humeralis (v.Ros.), Hendel, 1936.

Location of holotype: Museum für Naturkunde, Stuttgart, Germany.

The distinctive features of this species are: frons bright yellow, orbits largely black, antennae black, notopleural area yellow, legs entirely black, squamae and fringe yellow, wing length about 2 mm., discal cell small, last segment of vein m4 three times length of penultimate.

I have examined the specimen recorded by Malloch (1923: 622) as *Agromyza artemisiae* Kalt. and it is clear that the species is in fact *humeralis*.

The larva forms a yellowish blotch-mine pupating in the leaf, and the main hosts are *Aster* spp. and *Erigeron* spp. I found the species to be abundant around Brisbane and Sydney at the end of January, 1961, and noted mines on *Aster subulatus.* Michx. and *Erigeron bonariensis L.* I have also seen specimens bred from *Aster* sp., Cairns, Qld., in January, 1960.

Distribution.—Queensland: Brisbane, Cairns; N.S.W.: Sydney; India; West Africa; Europe; North and South America. New to Australia.

Phytobia (Dizygomyza) poemyzina sp.n.

Head: frons little wider than eye viewed from above, not projecting above eye in profile, orbits distinctly differentiated, slightly widening anteriorly; two ors, the upper stronger than lower, two ori, similar to upper ors, lunule (fig. 45a) relatively broad and high, upper margin semi-circular; jowls narrow but extended at rear, cheeks linear; third antennal segment small in both sexes, rounded, without conspicuous pubescence, arista long, largely bare.

Mesonotum: 3 + 1 strong dc, third and fourth equal, acr regularly in four rows, coarse, extending almost to first dc, prescutellars well-developed, similar to ori.

Wing (fig. 46): length in male 2·4, in female 2·7 mm., discal cell small, penultimate segment of vein m4 thus short, two-thirds length of last segment, first cross-vein at or just before centre of discal cell.

Colour: frons, jowls, antennae matt black, orbits becoming paler in front, almost yellowish, lunule paler grey; mesonotum black, largely matt but with slight subshine, mesopleura with narrow, bright-yellow upper margin, pleura otherwise black, legs black, fore-femora narrowly yellow, abdomen shining black; wing base conspicuously yellow, squamae yellow, fringe basically pale, yellowish brown but at certain angles appearing darker, more contrasting.

Male genitalia: aedeagus (fig. 47) with characteristically curving tubules distally, mesophallus with large ventral appendage on left-side, which is only rudimentary on other side.

Holotype: ♂, N.S.W. Otford, 12.x.1957 (D.K.M.); 5 paratypes, 1 ♀ same data, on same mount as holotype, 1 ♂, 1 ♀, Blue Mountains, Mount Wilson, 30.x.1955 (D.K.M.), 1 ♀, Katoomba, 30.v.1958 (G. H. Hardy), 1 ♂, Mt. Kosciusko, no date (F. H. Taylor). Holotype and 3 paratypes in Australian Museum, Sydney, 1 paratype IHTM, 1 paratype in author's collection.

The form of lunule immediately places this species in the small group hitherto included in the sub-genus *Poëmyza* Hendel, consisting of *angulata* (Loew) (= *semiposticata* Hd.) (cf. Frick, 1959: 380), *scutellaris* (v.Ros.), *caricivora* Groschke, 1954, and also a new species from Africa (confirmed recently from examination of genitalia) previously (Spencer, 1959: 303-4) identified as *caricivora*. The lunule of this group is intermediate between the broad, low lunule (fig. 45b) of *Dizygomyza* Hendel s.s. and the narrow, high lunule of *Poëmyza* Hendel (fig. 45c). Recent studies of genitalia by Nowakowski (1962), which I have been able to confirm, show that *Dizygomyza* and *Poëmyza* cannot justifiably be treated as separate sub-genera and the exact status of what may conveniently be called the *angulata* group thus no longer arises. For the time being I maintain *Dizygomyza* as an enlarged sub-genus of *Phytobia* Lioy, now including *Poëmyza*.

The new species is immediately distinguishable from other members of the group by the longer last segment of vein m4 and also by the shorter lower ors; the yellow marking on the fore-femora is also less distinct.

The larvae of the other species are all leaf-miners on Cyperaceae, and there seems little doubt that *poemyzina* feeds on a similar host-plant.

Phytobia (Icteromyza) triplicata sp.n.

Head: frons relatively broad, in ratio 11: 7 with eye viewed from above, orbits distinctly projecting above eye in profile; two equal ors directed upwards, normally three ori directed inwards, the upper similar to ors, the second only slightly weaker, the front one short, slight; orbital setulae short, sparse, reclinate; lunule broad and high, distance from upper margin to base of antennae similar to that to foremost ocellus; jowls broad, extended at rear, in centre one-fifth vertical height of eye; eye oval, slanting; third antennal segment relatively large, slightly longer than broad, rounded at end, arista slightly shorter than vertical height of eye, moderately pubescent.

Mesonotum: 3 + 1 dc, decreasing uniformly in size, acr coarse, irregularly in four rows.

Wing: length in male 2·2 mm., in female up to 2·7 mm., costa extending strongly to vein m1 + 2, which ends at apex of wing, costal segments 2, 3, 4 in ratio 40: 12: 10, rm at midpoint of discal cell, segments of m4 variable but last and penultimate normally equal.

Colour: frons, lunule, lower orbits, jowls, palps dirty yellow, upper orbits darkened, blackish-brown, hind margin of eye black, first antennal segment yellow, second black at base, yellow apically, third predominantly dark but distinctly yellowish on inside, mesonotum greyish-black, matt from front, more shining from behind. Pleura more distinctly black, brownish at margins, abdomen shining black; legs: coxae mainly black but on fore and mid legs yellow at apex, femora black, bright yellow on all legs on anterior quarter, tibiae brownish-black, yellowish at base adjoining femora, tarsi uniformly dark; wing base conspicuously yellowish, squamae yellow, fringe yellowish-ochrous, halteres yellow.

Male genitalia: aedeagus distinctive, as illustrated (fig. 48).

Holotype ♀, N.S.W., Pacific Highway, south side of Hawkesbury River, 13.x.1956 (lowest specimen of 4 on same mount); 18 paratypes: 3 ♂, same data as holotype; National Park near Sydney, 1 ♂, 1 ♀, 14.x.1956, 1 ♂, 13.xii.1956, 1 ♂, 4.xi.1956; 1 ♂, Burragorang, 12.i.1957; 1 ♂, Blue Mountains, Wentworth Falls, 29.xi.1958, 1 ♂, 3 ♀, Bargo, 22.ix.1956, 1 ♀, Baerani Creek, near Denman, 29.viii.1956, 1 ♀, Paddy's River, near Marolan, 22.ix.1956, 2 ♂, Hartley, 20.ix.1956 (all D.K.M.); 1 ♂, A.C.T., Black Mountain, 8.x.1930 (A. L. Tonnoir). Holotype and 12 paratypes in Australian Museum, Sydney, 1 ♂, C.S.I.R.O., Canberra, 3 ♂, 2 ♀ in author's collection.

A number of species in this sub-genus are extremely close morphologically, but there are consistent differences in the genitalia of the six species I have been able to examine. It has been found in the closely related sub-genera *Poëmyza* Hendel and *Dizygomyza* Hendel and also in *Cerodontha* Rondani that in very similar species slight but constant differences in the genitalia are invariably associated with distinctive differences in larvae and biology.

The biology is known of only two of this group of *Icteromyza* spp. Frick (1959: 38) reports rearing *I. longipennis* (Loew), 1869 from leaf and stem-mines on *Juncus xiphiodes* Meyer. It is believed that *I. capitata* (Zett.) also feeds on *Juncus* sp. and it seems probable that *triplicata* and the other species in the group have a similar host plant.

I have recently been able to examine the genitalia of a specimen of *longipennis* kindly sent me by Dr. Frick (fig. 49). It will be seen that the aedeagus is significantly different from that of *triplicata*, although the only difference in the adults is in the degree of yellow on the femora.

The following partial key of *Icteromyza* spp. permits identification of eight species of the subgenus with which I am familiar.

1. Palps black .... *capitata* (Zett.)
   Palps yellow 2
2. Frons entirely brown; small species, wing length 1·7-1·9 mm. .... *floresensis* Spencer
   Frons largely yellow; larger species, wing length 2·2-2·7 mm. 3
3. Orbits yellow; last segment of vein m4 shorter than penultimate .... *nigricoxa* (Malloch)
   Upper orbits dark, black or brown; last segment of m4 longer than penultimate .. 4
4. Femora entirely yellow .... *piliseta* (Becker)
   Femora only partially yellow 5
5. Femora yellow on anterior third .... *longipennis* (Loew)
   Yellow at apex of femora equal to width of femora 6
6. Third antennal segment entirely black; median section of aedeagus without curvature, forming straight line with distiphallus which only curves up at end, both pale, scarcely chitinized .... *geniculata* (Fallén)
   Third antennal segment partially yellow; median section of aedeagus with conspicuous curvature 7
7. Tubules of distiphallus conspicuously swollen at end (Spencer, 1961: fig. 44) .... *duplicata* Spencer
   Tubules of distiphallus uniformly tapering, not swollen at end (fig. 48).. *triplicata* Spencer

Phytobia (Praspedomyza) incerta sp.n.

Head: frons scarcely wider than eye, not projecting above eye in profile; two strong, equal ors, two ori, the upper somewhat weaker than ors, the lower still weaker; orbits well defined but not significantly raised above frons, ocellar triangle only weakly defined beyond foremost ocellus, apex at level of upper ors, lunule narrow, upper margin forming semicircle; eye large, upright, oval, jowls extremely narrow, forming only narrow line below eye, vibrissa strong, equal to ors; third antennal segment small, rounded, arista long, equal to vertical height of eye, appearing bare.

Mesonotum: 3 + 1 dc, first and second strong, third and fourth equal, weak, half length of first, equidistant each side of suture, acr irregularly in six rows in front, a few scattered hairs extending to first dc, inner post-alar strong, equal to second dc, prsc lacking.

Wing: length in male 2 mm., costa extending to vein m1 + 2, discal cell large, rm just before midpoint, last and penultimate segments of m4 equal.

Legs: mid-tibiae with two well-defined postero-dorsal bristles.

Colour: frons matt black, orbits distinctly shining, lunule more grey, antennae black; mesonotum black, largely matt, slightly shining from behind, legs entirely black, abdomen moderately shining black; wing clear, veins black, squamae grey, fringe black.

Male geniatlia: aedeagus as illustrated (fig. 50), postgonites long, club-shaped dorsally, surstyli bearing one strong spine.

Holotype: ♂, North Queensland, Mulgrove River, 4 miles west of Gordonvale, 4.i.1959 (D.K.M.), Australian Museum, Sydney.

The exact position of this species within the genus is not clear. There are a number of characters associating it with *Praspedomyza* and it can most conveniently be provisionally placed in this sub-genus. The aedeagus is strikingly similar to that of many *Liriomyza* spp.; Nowakowski (in litt.) has mentioned the affinity he has found between the genitalia of *Praspedomyza* and *Liriomyza*.

Phytobia (Praspedomyza) pittosporocaulis Hering, 1962

Location of holotype: Department of Agriculture, Entomological Branch, Sydney.

On morphological characters this species seems correctly placed in the sub-genus Praspedomyza, generally resembling a number of Palaearctic species.

I have recently examined the genitalia of a male paratype, kindly presented to me by Professor Hering, and the aedeagus is illustrated in fig. 51. The distiphallus consists of long, tapering, paired tubules; the mesophallus is represented by two small black sclerites, with the basiphallus largely membranous and indistinct; there are four distinct spines on the surstyli. The aedeagus of the closely related species, *pittosporophylli* Hering, is generally similar but with slight distinctive differences (fig. 52).

This species is readily distinguishable from *pittosporophylli* by its largely yellow third antennal segment.

The larva forms twig galls on *Pittosporum undulatum* Andr. Both larva and gall have been discussed in detail by Hering (1962).

Distribution: N.S.W.: Normanhurst, Sydney, Seaforth.

Phytobia (Praspedomyza) pittosporophylli Hering, 1962

Location of holotype: Department of Agriculture, Entomological Branch, Sydney.

This species closely resembles *pittosporocaulis* Hering but is immediately distinguishable by its entirely black third antennal segment.

The aedeagus of a paratype, kindly presented to me by Professor Hering, is illustrated in fig. 52. The paired tubules of the distiphallus are considerably shorter than in *pittosporocaulis* but they are broader basally, the two sclerites of the mesophallus are larger and less strongly chitinized. On the surstyli there is a row of about 20 short, stout spines.

The larva forms leaf-galls, normally near the mid-rib but also elsewhere in the leaf, on *Pittosporum undulatum* Andr. Larva and gall have been described in detail by Hering (1962).

Distribution: N.S.W.: Normanhurst, Roseville, Sydney.

Genus **Liriomyza** Mik

Liriomyza Mik, 1894, Wien.ent. Zeitung, 13: 284.

Type species: *Liriomyza urophorina* Mik, Europe.

This is one of the larger genera in the Palaearctic, Nearctic and Neotropical regions but is reduced to a few species only in the Ethiopian and Oriental regions. In Australia, with 16 per cent. of the described species, it has double the percentage of the Oriental region.

The majority of the species are leaf-miners. The biology is known for only three of the nine Australian species, six of which are endemic. At least two of the undescribed species discussed on pp. 338-9 appear to belong to this genus.

Key to Australian Liriomyza species

1. Second cross-vein lacking 2
   Second cross-vein present 3
2. Mesonotum pale ash-grey, hind-margin of head entirely yellow, four orbital bristles .... *caulophaga* (Kleinschmidt)
   Mesonotum black, slightly shining, hind margin of head black beyond vertical bristles, three orbital bristles .... *chenopodii* (Watt)
3. Scutellum distinctly bright yellow, at least in centre 4
   Scutellum largely black, only faintly yellow distally .... *helichrysi* sp.n.
4. Third antennal segment partially darkened, black or brown 5
   Third antennal segment entirely yellow 8
5. Mesonotum yellow centrally adjoining scutellum .... *australina* sp.n.
   Mesonotum dark to margin of scutellum 6
6. Orbital setulae and acrostichals lacking .... *singularis* sp.n.
   Orbital setulae and acrostichals present 7
7. Mesonotum uniformly matt grey, acr in 2 rows .... *pallidicentralis* Mall.
   Mesonotum brown-dusted between dc, with grey-dusted bands laterally, acr in 4 rows .... *tricolor* Mall.
8. Mesonotum shining black, frons bright yellow, at most orbits darkened, mesopleura largely yellow .... *brassicae* (Riley)
   Mesonotum matt black, frons brownish, mesopleura largely black .... *obscurata* sp.n.

Liriomyza australina sp.n.

Head: frons twice width of eye, not significantly projecting above eye in profile; two equal ors directed upwards, one weaker ori directed inwards; orbital setulae lacking; jowls rounded, deepest in centre, one-third vertical height of eye; eye upright, oval, with distinct, short pilosity; third antennal segment small, round, with conspicuous pubescence, arista short, bare.

Mesonotum: 3 + 1 dc, third and fourth equal, two-thirds length of second, second only slightly shorter than first; acr sparse, only one or two individual hairs between third and fourth dc.

Wing: length in female 1·6 mm., in male 1·1-1·25 mm.; first cross vein at mid-point of discal cell, last segment of m4 one-and-a-half times length of penultimate.

Colour: frons, jowls, face bright yellow; third antennal segment black, first and second yellow; palps yellow at base, brown distally; mesonotum (fig.53) with three matt, greyish-black bands, the central one between the dc extending from front of dorsum to midway between first and second dc; two narrower lateral bands from just before level of fourth dc to level of first; laterad of these outer bands, mesonotum bright yellow extending down to pleura; broad central yellow area at rear of mesonotum adjoining scutellum which is entirely yellow in holotype but laterally grey in both paratypes; pleura predominantly yellow but sterno-pleura with central black triangle, hypopleura with smaller, circular black area and narrow black strip at upper margin of notopleural area; abdomen entirely yellow, apart from shining black ovipositor in female and matt black epandrium in male; legs: yellow, tibiae and tarsi slightly darker, yellowish-brown; halteres yellow.

Holotype ♀, N.S.W., Blue Mountains, Springwood, Sassafras Gully, 17.xi.1956, in Australian Museum, Sydney, paratypes 2 ♂, one N.S.W., Otford, 12.x.1957; one, same data as holotype (all D.K.M.); one paratype in author's collection, other in Australian Museum.

This species is immediately distinguishable from all others in Australia by three dark bands and the yellow central area on the mesonotum adjoining the scutellum; it is the smallest species known in the world with this conspicuous colour pattern.

Liriomyza brassicae (Riley)

Agromyza brassicae Riley, 1844.

Liriomyza brassicae (Riley), Hendel, 1936.

Location of holotype: USNM.

This is the species identified by Malloch (1925: 90; 1927: 426) as *pusilla* (Mg.). There are no confirmed records of *L. pusilla* in Australia.

L. brassicae is a leaf-miner on Cruciferae and Capparidaceae and also occurs commonly on Tropaeolum (fig. 54). It can be a serious pest on cruciferous crops.

I have recently discussed this species in some detail (1961, 1961b, in press) and have shown the colour variation which can occur. The head, including antennae, is bright yellow but there is normally some degree of darkening of the orbits which can range from black to almost entirely yellow; a similar variation can occur in the mesopleura and also in the abdomen, where the tergites may be entirely black or conspicuously yellow laterally; the mesonotum is always shining black and the scutellum yellow.

I have noted the species on the following hosts:—

Tropaeolum major L., Sydney, Brisbane, Hobart.

Gynandropsis speciosa L., Sydney.

Raphanus raphanistrum L., Sydney.

Diplotaxis muralis (L.) DC, Hobart.

Distribution: Queensland, New South Wales, Tasmania; Hawaii; Micronesia; India; Africa; Europe; North America; British Guiana. New to Australia.

Liriomyza caulophaga (Kleinschmidt), comb.nov.

Haplomyza caulophaga Kleinschmidt, 1960.

Liriomyza haplomyzina Spencer, 1961, syn.nov.

Location of holotype: QM, Reg. No. T5810.

This is a distinctive species, with bright yellow head, including antennae and entire hind-margin of eye, matt ash-grey mesonotum, bright yellow legs and the second cross-vein lacking; there are two ors and two ori but orbital setulae are normally entirely lacking. The species has three of the four characters accepted by Frick (1959: 412) as defining species of the genus *Haplomyza*, the fourth being the presence of only a single upper orbital bristle. On this definition the species must be transferred to *Liriomyza*, since two upper orbitals are clearly present.

L. haplomyzina was described from a single specimen from Lombok, Indonesia, and the description was already in press when Kleinschmidt's (1960) paper describing *caulophaga* was published. I am satisfied that the two species are identical and therefore synonymize *haplomyzina* with *caulophaga* herewith.

The distinctive aedeagus and spermal sac of the species are illustrated in figs. 55a, b; the genitalia were also illustrated by Kleinschmidt (1960: 15).

The bright yellow head, projecting frons, ash-grey mesonotum, sparse or absent orbital setulae make this species readily distinguishable from *L. chenopodii* (Watt), in which the second cross-vein is also lacking.

The two type specimens were bred from the stalk of silver-beet, *Beta vulgaris* L. var. *cicla* L.

Distribution.—Queensland: Nudgee and near Nocundra; N.S.W.: Leeton, Wilcannia, Cobar; Indonesia: Lombok.

Liriomyza chenopodii (Watt), comb. nov.

Haplomyza chenopodii Watt, 1924.

Haplomyza imitans Malloch, 1934, syn. nov.

Location of holotype: Dominion Museum, Wellington.

Malloch's description of this species, which is reasonably complete, agrees closely with that of Watt, which appears to have been overlooked. The species has further been redescribed by Harrison (1959: 327). I have compared Australian specimens with paratypes of *chenopodii* kindly lent me by Professor Hering, Berlin, and, as they are identical both in external morphology and in the male genitalia, I synonymize *imitans* with *chenopodii* herewith.

This is a typical Liriomyza but has been placed in Haplomyza on the basis of the absence of the second cross-vein. Frick (1952) has recently redefined Haplomyza, including in it only species with the following combination of characters: one ors, matt-grey mesonotum, acr in two rows, second cross-vein lacking. The species under discussion has only the last of these characters and should thus be transferred to Liriomyza.

The essential characters of the species are: two reclinate ors, one incurved ori, head including antennae bright yellow but small area on hind margin of eye beyond vte black; mesonotum black, only moderately shining; pleura predominantly yellow, mesopleura with small black patch on lower margin; femora bright yellow; second cross-vein lacking; abdomen shining black, tergites with narrow yellow borders. Male genitalia as in fig. 55a, b.

Watt (1924) also describes the biology. The larva forms a linear leaf-mine and hosts recorded in Australia include *Beta vulgaris L.*, *Spinacia oleracea L.*, *Stellaris media* (L.) Vill. and wallflower.

Distribution.—New South Wales: Hornsby, Bronte, National Park, near Sydney, Granville; New Zealand.

Liriomyza helichrysi sp.n.

Head: frons one-and-a-half times width of eye, not projecting above eye in profile; two ors, the upper longer and directed upwards, the lower directed partially inwards; two equal ori directed largely inwards; orbital setulae sparse, minute; jowls deep, four-tenths length of eye; eye distinctly slanting; third antennal segment small, rounded, with long, upward pubescence.

Mesonotum: 3 + 1 dc, first and second long, third and fourth substantially smaller; third immediately behind suture, fourth somewhat in front; acr sparse, in two rows, from before fourth dc to level of second.

Wing (fig. 57): length in male 1·35 mm., in female 1·75 mm.; first cross-vein beyond centre of discal cell, second conspicuously oblique.

Colour: frons, jowls, antennae yellow; upper orbits slightly darkened, blackish, both vte and vti on black ground; mesonotum black but largely matt, only slightly shining; scutellum appearing entirely black but with faint trace of yellow between hind scutellar bristles, when viewed from behind; pleura largely blackish; upper margin of sternopleura and mesopleura dirty-yellowish, humerus and notopleural area also yellowish; legs: coxae black but in fore-legs slightly yellowish; femora basically yellow but distinctly blackish above, tibiae and tarsi dark brown; abdomen black.

Male genitalia: aedeagus as figured (fig. 58a); basal half of median section only visible as a narrow, strongly chitinized line; spermal sac conspicuously small (fig. 58b).

Puparium: 1·5 mm. long, brownish-yellow, posterior spiracles each with three buds.

Leaf-mine: an irregular, upper surface channel which finally runs for a short distance on the lower surface, where pupation takes place; frass deposited in only a few large, widely separated lumps.

Holotype: ♂, emerged 7.ii.1961 from leaf-mines on *Helichrysum brachteatum* (Vent). Andr., Mount Gibraltar, near Bowral, New South Wales; two male, one female paratypes, same data (all K.A.S.); holotype and two paratypes in author's collection, one paratype presented to Australian Museum, Sydney.

This species is a typical Liriomyza but is unusual in having an almost entirely black scutellum. Empty leaf-mines were also found at Clyde Mountain, N.S.W., and the species is probably widespread with its host-plant.

Distribution.—New South Wales: Bowral, Clyde Mountain.

Liriomyza obscurata sp.n.

Head: frons one-and-a-half times width of eye, not significantly projecting above eye in profile; two equal ors directed upwards, two ori directed inwards and slightly upwards, the lower distinctly weaker; orbital setulae sparse, minute; orbits well-defined; jowls angular, deepest at rear, cheeks forming linear ring below eye; third antennal segment conspicuously round, almost bare, arista long, equal to vertical height of eye.

Mesonotum: 3 + 1 dc, first, second and third well-developed, fourth small, half length of third; acr sparse, in two rows only between first and second dc.

Wing: length in male 1·75 mm., in female up to 2·3 mm.; first cross-vein opposite termination of vein r1, beyond centre of discal cell; last segment of m4 in ratio 24: 9 with penultimate.

Colour: frons distinctly darkened, brownish; orbits paler, more yellowish in front but black above; both vti and vte on black ground, hind-margin of head entirely black; jowls, face, palps orange-yellow, antennae brighter, more lemon-yellow; mesonotum black, without any yellow at hind corners, largely matt but slightly shining, notopleural area yellow, pleura otherwise almost entirely black, mesopleura narrowly yellow on upper margin; scutellum yellow in centre, black on lateral corners; legs: coxae largely black, though front pair paler, more yellowish; femora yellow, tibiae and tarsi brownish-black; abdomen black, only weakly shining; wing normal, squamae and fringe dark, blackish.

Male genitalia: aedeagus and spermal sac as illustrated (figs. 59a, b).

Holotype: ♂, New South Wales, Tubrabucca to Moonan, c. 2,000 ft., Upper Hunter, 19.x.1956 (D.K.M.), Australian Museum, Sydney; paratypes: Blue Mountains: 1 ♂ Springwood, Sassafras Gully, 17.xi.1956, 1 ♂, Mount Wilson, 30.x.1958; 1 ♀, Mount Tomah, 5.x.1957; 1 ♀, Lawson, 3.xii.1956; 1 ♂, 1 ♀, Belltrees, near Scone, N.S.W., 20.x.1956; 3 ♀, Bronte, near Sydney, 5.x.1958; 1 ♂, National Park, 3.xi.1956 (all D.K.M.); 1 ♂, 1 ♀ in author's collection, remainder in Australian Museum, Sydney.

This is a conspicuously dark species, readily distinguishable from all others known from Australia.

Liriomyza pallidicentralis Malloch, 1927

Location of holotype: IHTM.

The species has a largely brown third antennal segment, matt grey mesonotum, acr in two rows and a narrow yellow strip down the centre of the scutellum; the eye is small, slanting wing length 2 mm., with the first cross-vein at the centre of the discal cell and the last segment of m4 slightly larger than the penultimate.

Distribution.—N.S.W.: Sydney.

Liriomyza singularis sp.n.

Head (fig. 60): frons unusually broad, over twice width of eye viewed from above, orbits raised, conspicuously projecting above eye in profile; two ors directed upwards and slightly outwards, the lower slightly weaker, two equal ori directed inwards, similar to lower ors, orbital setulae lacking, lunule small and low, below raised frons; jowls very broad, extended at rear, one half vertical height of eye, cheeks forming conspicuously broad band below eye, eye oval, slightly slanting; third antennal segment large, broadening distally, rounded at end, arista appearing bare.

Mesonotum: 3 + 2 dc, second, third and fourth equal, only slightly smaller than first, fifth distinctly weaker, little more than half length of fourth (on one side even smaller), acr virtually lacking, only a single isolated hair present, no hairs in inter-alar area, inner post-alar strong, similar to fifth dc.

Wing: length in female 2·7 mm., rm at centre of discal cell, this large, penultimate segment of vein m4 thus only slightly shorter than ultimate, in ratio: 23: 27.

Legs: mid-tibiae without differentiated postero-dorsal bristles.

Colour: frons brownish, more yellow anteriorly, jowls, cheeks and orbits yellowish-brown, vti on brown area, vte on black but hind-margin of head beyond again becoming paler, yellowish; first and second antennal segments yellow, third black above, brownish-yellow below; mesonotum matt grey, diffused with yellow, appearing yellowish-brown from front, dark-grey from behind, scutellum matt-grey, with pale yellowish band along centre; pleura entirely dark-grey; legs basically yellowish but variably marked with grey, darker above, more distinctly yellow below, abdomen entirely matt black; wing dull, greyish, veins dark, squamae and fringe pale, yellowish.

Holotype: ♀, A.C.T., Blundell's, 26.xi.1930 (L. F. Graham), School of Hygiene and Tropical Medicine, Sydney.

This is a unique, distinctive species, immediately recognizable by the head shape, absence of orbital setulae and acrostichals and unusual coloration, particularly of the mesonotum.

Liriomyza tricolor Malloch, 1927

Location of holotype: USNM.

The essential features appear to be: head yellow, third antennal segment brownish above, " mesonotum fuscous except between the lateral margins, the dark part densely grey dusted except between the dorso centrals from near anterior margin, the central part brown dusted " (Malloch), abdomen yellow, last section of vein m4 twice length of penultimate, size 1·5 mm.

Malloch states that the species is distinguished from any species in Australia by the tricoloured thoracic dorsum.

Distribution.—N.S.W.: Como.

Genus **Phytoliriomyza** Hendel

Phytoliriomyza Hendel, 1931, in Lindner: Flieg.Palaearct. Reg. 59: 203.

Type species: *Agromyza perpusilla* Meigen, Europe.

This genus was erected by Hendel for the single Palaearctic species *perpusilla* Mg. Three additional species have subsequently been described or transferred to the genus from Hawaii, Greenland and Chile and a fourth species is shortly being described by the author from Scotland.

A distinctive new species from Australia is described below.

Phytoliriomyza australensis sp.n.

Head (fig. 61): frons broad, twice width of eye, not projecting above eye in profile; two ors directed upwards, the upper substantially stronger, one ori directed inwards, equal to lower ors; orbital setulae sparse, proclinate; jowls relatively deep behind, cheeks forming only narrow ring below eye; eye conspicuously slanting, variably covered with short hairs in both sexes; third antennal segment rounded, with distinct upcurved pubescence, arista conspicuously long, longer than maximum vertical height of eye.

Mesonotum: 3 + 1 dc, third at suture, fourth slightly in front of pre-suturals; acr entirely absent or present in two short rows.

Wing: length in male 1·4-1·5 mm., in female 1·5 mm.; costa extending strongly to vein m1 + 2, vein rm slightly basad of centre of discal cell, last segment of m4 relatively short, less than one-and-a-half times length of penultimate.

Colour: highly variable; frons yellowish brown, first and second antennal segments bright yellow, third basically yellow with varying degree of darkening above; mesonotum matt grey, pleura predominantly yellow, mesopleura with small slightly darker patch along lower margin, pteropleura with darker triangle varying from pale brown to black; abdomen varying from greyish-black to entirely yellow including epandrium; legs usually entirely yellow, tibiae and tarsi sometimes more distinctly brown; halteres yellow but knob sometimes darkened, brownish.

Male genitalia (fig. 62): aedeagus as illustrated, apex not reaching end of ninth sternite.

Holotype: ♂, National Park, N.S.W., 14.x.1956. 10 paratypes, 3 ♂, Blue Mountains, Jenolan, Camping Ground, c. 4,000 ft., 10.xii.1956; 3 ♂, Blue Mountains, Lawson 3.xii.1956, 1 ♂, Bronte near Sydney, 28 xi. 1955, 1 ♂, Qld., Atherton Tableland, head of Clohesy River, 20.v.1956, 2 ♀, Blue Mountains, Springwood, Sassafras Gully, 17.xi.1956, 1 ♀, N.S.W., Pacific Highway, 1 mile south of Hawkesbury River, 29.ix.1956 (all D.K.M.). Holotype and 7 paratypes in Australian Museum, Sydney, 2 ♂, 1 ♀ paratypes in author's collection.

This small species resembles in size *P. montana* Frick, 1953, from Hawaii, in which wing length varies from 1·25-1·6 mm. *P. montana* is a conspicuously dark species, in which the third antennal segment and the greater part of the mesopleura are constantly black; in this species the distal tubules of the aedeagus extend far beyond the end of the ninth sternite, immediately distinguishing the species from *australensis.*

The new species has been compared with a number of specimens of *P. perpusilla* (Mg.) and apart from the smaller size can be distinguished by the consistently dark scutellum, the longer arista and the larger discal cell; in *australensis* the ratio of the last to the penultimate segment of vein m4 is 1-1·3: 1, whereas in *perpusilla* the last segment is at least twice as long as the penultimate. In the three paratypes of *montana* I have examined, this ratio is 1·5-2: 1 and the three species can be virtually separated on this character alone.

The following key permits identification of the three confirmed species considered above:—

1. Wing length 1·4-1·6 mm.; last segment of vein m4 normally less than twice length of penultimate 2
   Wing length 1·75-2·3 mm.; last segment of vein m4 at least twice as long as penultimate; aedeagus long, twice length of ninth sternite .... *perpusilla* (Mg.).
2. Third antennal segment and mesopleura largely yellow; last segment of m4 at most one-and-one-third times length of penultimate; aedeagus short, apex not reaching end of ninth sternite (fig. 62) .... *australensis* Spencer
   Third antennal segment and mesopleura largely black; last segment of m4 one-and-a-half to twice length of penultimate; aedeagus long, twice length of ninth sternite .... *montana* Frick

The exact position of *imperfecta* (Malloch), 1934 from Chile and *arctica* (Lundbeck) (cf. Frick, 1952) from Greenland and North America remains to be clarified.

Genus **Pseudonapomyza** Hendel

Pseudonapomyza Hendel, 1920, Arch. Naturgesch. Abt.A., 84: 15.

Type species: *Phytomyza atra* Meigen, Europe.

This small genus of 10 species was erected for the single Palaearctic species, *atra* Mg. having a conspicuous angle to the third antennal segment and characteristic wing venation, with a short costal segment between veins r1 and r2. *P. spicata* (Malloch), which is widespread throughout the Pacific area agrees exactly with Hendel's original concept and the larva also has distinctive papilli as in *atra* Additional species without the characteristic angle to the third antennal segment and also without the distinctive venation of *atra-spicata* have since been placed in this genus on the basis of genitalial and larval affinities (Spencer, 1961, and 1961b). The genitalia of these species were illustrated by Spencer (1961: figs. 46-48).

Pseudonapomyza spicata (Malloch)

Phytomyza spicata Malloch, 1914.

Pseudonapomyza spicata (Malloch), Hennig, 1941.

Location of neotype: HNM.

This is a very small black species, with wing length of 1·65 mm. It can be recognized by the sharp angle at the upper corner of the third antennal segment, shining black mesonotum and white squamae and fringe. The species has recently been discussed in detail by Spencer (1961: 93 and in press).

The larvae form leaf-mines on numerous Gramineae, including sugar and corn (*Zea*), where severe damage can be caused to the growth of young plants; the larva pupates on the ground. I have found mines and larvae on *Eleusine indica* (L.) Gaertn., on 4.ii.61 at Sydney and on *Brachiaria miliformis* (Presl.) Chase on 22.i.1961, at Darwin.

Distribution.—New South Wales: Sydney; N.T.: Darwin; Fiji, Samoa, Hawaii, Micronesia, Formosa. New to Australia.

Genus Phytomyza Fallén

Phytomyza Fallén, 1810, Nov. Dipt. Dispon. Method., p. 21, No. 67.

Type species: *Phytomyza flaveola*, Fallén, Europe.

Only four species of this large genus have so far been recorded in Australia, and two are common European species which have almost certainly been introduced in recent times.

Key to Australian Phytomyza species

1. Scutellum at least partially yellow .... *vitalbae* Kalt.
   Scutellum uniformly black or grey 2
2. Femora entirely bright yellow .... *clematidicolla* sp.n.
   Femora at most yellow at knees 3
3. Third antennal segment small, round; acrostichals normally lacking .... *atricornis* Mg.
   Third antennal segment larger, elongated; some acrostichals normally present .... *plantaginis* R.-D.

Phytomyza atricornis Meigen

Location of holotype: believed lost.

This is the most widespread and polyphagous species of the Agromyzidae. It is readily recognizable by the yellow frons, round, black, third antennal segment and matt ash-grey mesonotum, normally entirely without acrostichals.

The larva forms an upper or lower surface, narrow, linear mine, pupating in the mine. Host plants on which I have noted the species in Australia are:—

Bidens pilosa L.
Chryanthemum maximum Ramond
Cirsium vulgare (Savi) Ten.
Coreopsis sp.
Helichrysum rutidolepis DC
Senecio dryadeus Sieb. ex Spreng.
S. lautus Forst.f. ex. Willd.
S. linearifolius A. Rich.
S. minimus Poir.
S. pterophorus DC.
Sonchus oleraceus L.

Distribution: New South Wales; Canberra; Victoria; Tasmania; South Australia; Queensland.

Phytomyza clematidicolla sp.n.

Head (fig. 63): frons almost twice width of eye viewed from above, slightly projecting above eye in profile at base of antennae; two equal ors directed upwards, one similar ori directed inwards; orbital setulae short, sparse, none above lower ors; jowls deeply extended at rear, little less than half vertical height of eye, cheeks forming broad ring below eye; third antennal segment large, conspicuously longer than broad; arista long, somewhat longer than maximum height of eye.

Mesonotum: 3 + 1 dc, second, third and fourth equal, acr in two rows, present only between third and fourth dc.

Wing: length in male 2·2-2·3 mm., ratio between second, third and fourth costal segments 33: 7: 15 in holotype, 38: 9: 18 in paratype.

Colour: frons, jowls, face and palps bright orange-yellow, third antennal segment black, first and second yellow, mesonotum and scutellum uniformly dark matt-grey; pleura predominantly blackish-grey, mesopleura narrowly yellow on upper and hind margin; legs: coxae and femora bright yellow, tibiae and tarsi dark-brownish; abdomen black, fore-segments slightly yellow laterally and all segments may have narrow yellow hind margins, wing normal, veins dark, squamae grey, fringe black.

Male genitalia (fig. 64): aedeagus as illustrated.

Puparium (fig. 65): orange-brown, segment boundaries indistinct, anterior spiracular processes relatively long, black, projecting through leaf epidermis, hind spiracles shorter, strongly chitinized at apex, each bearing nine buds.

Leaf-mine (fig. 66): a narrow, winding, upper-surface channel with frass deposited in conspicuous strips at alternate sides of the mine (fig. 67a); pupation takes place in the mine.

Holotype: ♂, A.C.T., Bull's Head, emerged 22.ii.1961, from leaf-mines found, 5.ii.1959, on *Clematis aristata* R. Br. ex DC (A. L. Dyce); one ♂ paratype N.S.W., Blue Mountains, Springwood, Sassafras Gully, 17.xi.1956 (D.K.M.). Holotype in author's collection, paratype in Australian Museum, Sydney.

Leaf-mines of this species were also found by the author on the same host at Mount Gibraltar, Bowral, N.S.W., on 30.i.61 and at Ferntree Gully, Victoria, on 9.ii.1961, but no adults were reared.

Leaf-mines of this species occur commonly, often on the same leaf, together with those of *P. vitalbae* Kalt. In the latter species, however, the larva pupates on the ground and the frass arrangement is quite different (fig. 67b).

The adult of *clematidicolla* is readily distinguishable from *vitalbae* by the entirely yellow femora, uniformly dark scutellum and presence of two ors; it can be distinguished from *clematadi* Watt, 1924, from New Zealand, which also pupates in the mine by the difference in the third antennal segment which is yellow and rounded in the latter species. The aedeagus is shown in fig. 68.

This brings to 16 the species of this genus known to feed on *Clematis* spp.

Phytomyza plantaginis R.-D.

Location of holotype: Musée d'Histoire Naturelle, Paris.

This species somewhat resembles *atricornis* Mg., but can be distinguished by the more prominent orbits, larger, somewhat elongated third antennal segment and presence of a few scattered acrostichals.

The larva forms a whitish linear mine on *Plantago* spp., pupating in the mine.

In a short, bred series from Tasmania (C.S.I.R.O., Canberra) the orbits and jowls are distinctly grey and the frons brownish; this appears to represent a dark, local Tasmanian form.

Distribution.—New South Wales: Broadwater, Bargo, Bowral; Canberra; Tasmania: Launceston. New to Australia.

Phytomyza vitalbae Kaltenbach

Location of holotype: auctioned in London in 1880, now believed lost.

This species has been described in detail by Hendel (1936). It is one of the small group with a partially yellowish scutellum and has a yellow frons and rounded black third antennal segment. It is immediately recognizable among Australian species by having only a single ors and a single ori. The distinctive aedeagus is illustrated in fig. 69, and suggests that the species is not closely related to the other Australian Clematis feeder, *P. clematidicolla* Spencer.

The larva forms an upper-surface, irregularly winding, linear leaf-mine on *Clematis* spp., and known Australian hosts are *C. aristata* R. Br. ex DC and *montana* Buch.-Ham. ex D.C.

The leaf-mines may occur together with those of *P. clematidicolla*, but can be immediately recognized by the characteristic arrangement of frass which is deposited for long stretches at alternate sides of the channel (fig. 67b); pupation takes place on the ground.

Distribution.—N.S.W.: Clyde Mountain, Bowral; A.C.T., Canberra; Europe. New to Australia.

Additional Unidentified Species

1. Leaf-mines on *Billardiera scandens* Sm.

Mines with young larvae were found at National Park, near Sydney, on 29.i.1961, and empty mines on 3.ii.1961, at Careel Bay, near Sydney. Mines with larvae have recently been reported at Hornsby, near Sydney (A. Dyce).

The mine (fig. 70) is irregularly linear, entirely upper-surface, with the black frass scattered along the centre of the channel. The larva leaves the mine to pupate and forms a brownish puparium.

The species concerned is almost certainly a *Liriomyza* sp.

2. *Leaf miner on Cassinia aculeata* R.Br.

Empty mines found at Otford, N.S.W., on 29.i.1961. The mine fills the upper half of the narrow leaves and normally measures ½ in. x ⅛ in.

3. Leaf mine on *Cassinia aureonitens* N.A. Wakefield and *Helichrysum dendroideum* N.A. Wakefield. Empty mines found on *Cassinia* on 29.i.1961, at National Park, near Sydney (K.A.S.).

The mine (fig. 71) starts as a narrow, linear, upper-surface channel with frass in distinct strips at alternate sides of the mine; in the second instar the mine greatly widens and the frass is deposited in larger black lumps.

Similar mines were found on *Helichrysum* on 9.ii.1961, at Ferntree Gully, near Melbourne.

4. Stem borer on *Cassinia aureonitens.*

An empty puparium found in the stem, data as 3 above, belongs to an undescribed *Melanagromyza* sp. The puparium is pale whitish, with indistinct segmentation but distinctive posterior spiracular processes (fig. 72); each process has 4 or 5 rather large buds with a small black horn above and the two processes are separated by their own diameter.

5. Leaf-miner on *Desmodium polycarpum* DC.

Mines found on Mt. Coot-tha, Brisbane, 22.i.1961. Oviposition takes place beside the mid-rib, where a narrow linear channel is formed; the mine subsequently greatly widens, becoming a conspicuous linear-blotch, centrally filled with diffused blue frass (fig. 73). The black puparium remains at the end of the mine with the anterior spiracles projecting through the epidermis. This is the only mine known to me in which the frass is so distinctively blue. The species is almost certainly a *Melanagromyza* sp.

6. Leaf-miner on *Goodenia ovata* L.

A single blotch-mine (fig. 74) found on 9.ii.1961, at Ferntree Gully, near Melbourne, together with a number of the characteristic linear mines of *Ophiomyia goodeniae* Spencer, represents a distinct species.

The yellowish blotch is on the lower surface, with frass in fine, black, scattered grains. The puparium is brown with the posterior spiracles in the form of two short projections surmounted by numerous minute buds.

7. Leaf-miner on *Oplismenus compositus* (L.) Beauv.

Mines with larvae feeding were found on 5.ii.1959, at Cabbage Tree Creek, Clyde Mountain, N.S.W.

The mine (fig. 75) is upper-surface, initially linear, but gradually filling the entire leaf, and is filled with diffused, greenish frass. Two or more larvae may feed together. The reddish-brown puparium is illustrated in fig. 76. The species is probably an *Agromyza* sp.

8. Stem borer in *Senecio pterophorus* DC.

Empty puparia found in stems, Mt. Lofty, Adelaide, 13.ii.1961. The puparium is pale whitish, with distinctive posterior spiracular processes. The two processes are separated by their own diameter and each bears a long, tapering horn ringed by 10 well-defined buds (fig. 77). The buds are far paler and less strongly chitinized than in the closely related species *M. seneciophila* Spencer (p. 319).

This appears to represent a further undescribed *Melanagromyza* sp.

9. Leaf-miner in *Senecio* sp.

Leaf-mines found at East Slope, Clyde Mountain, N.S.W., 5.ii.1961 (fig. 78).

One puparium was found in the mine but other mines were empty. It is relatively short and broad with distinct segmentation, shining reddish-brown.

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EXPLANATION OF FIGURES

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71. Agromyzid sp. Leaf-mine on *Cassinia aureonitens*, National Park, N.S.W.
72. *Melanagromyza* sp. Posterior spiracles of puparium ex stem of *Cassinia aureonitens*, National Park, N.S.W.
73. ? *Melanagromyza* sp. Leaf-mine on *Desmodium polycarpum*, Mt. Coot-tha, Brisbane.
74. Agromyzid sp. Leaf-mine on *Goodenia ovata*, Ferntree Gully, Vic.
75. ? *Agromyza* sp. Leaf-mine on *Oplismenus compositus*, Clyde Mt., N.S.W.
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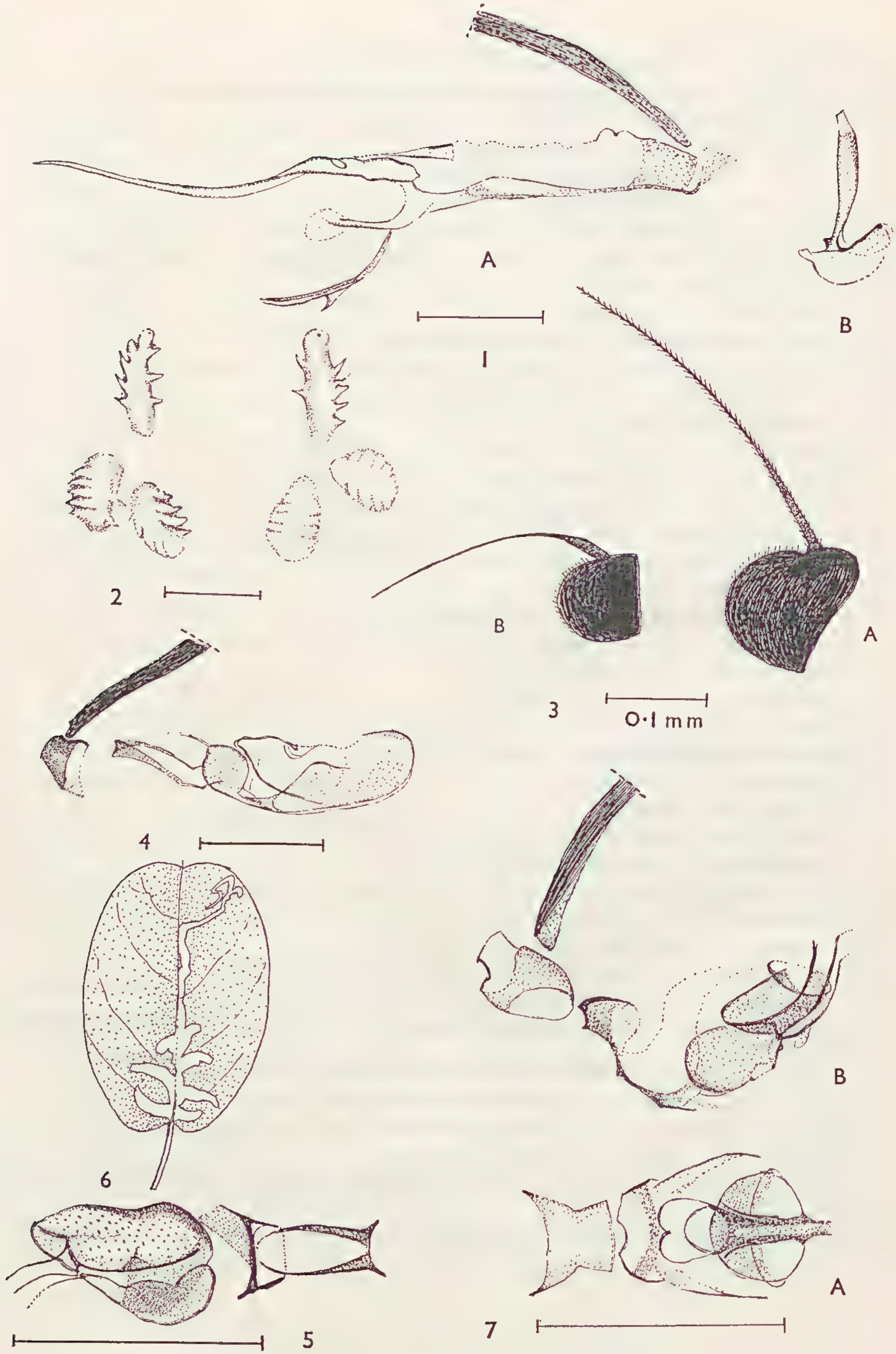
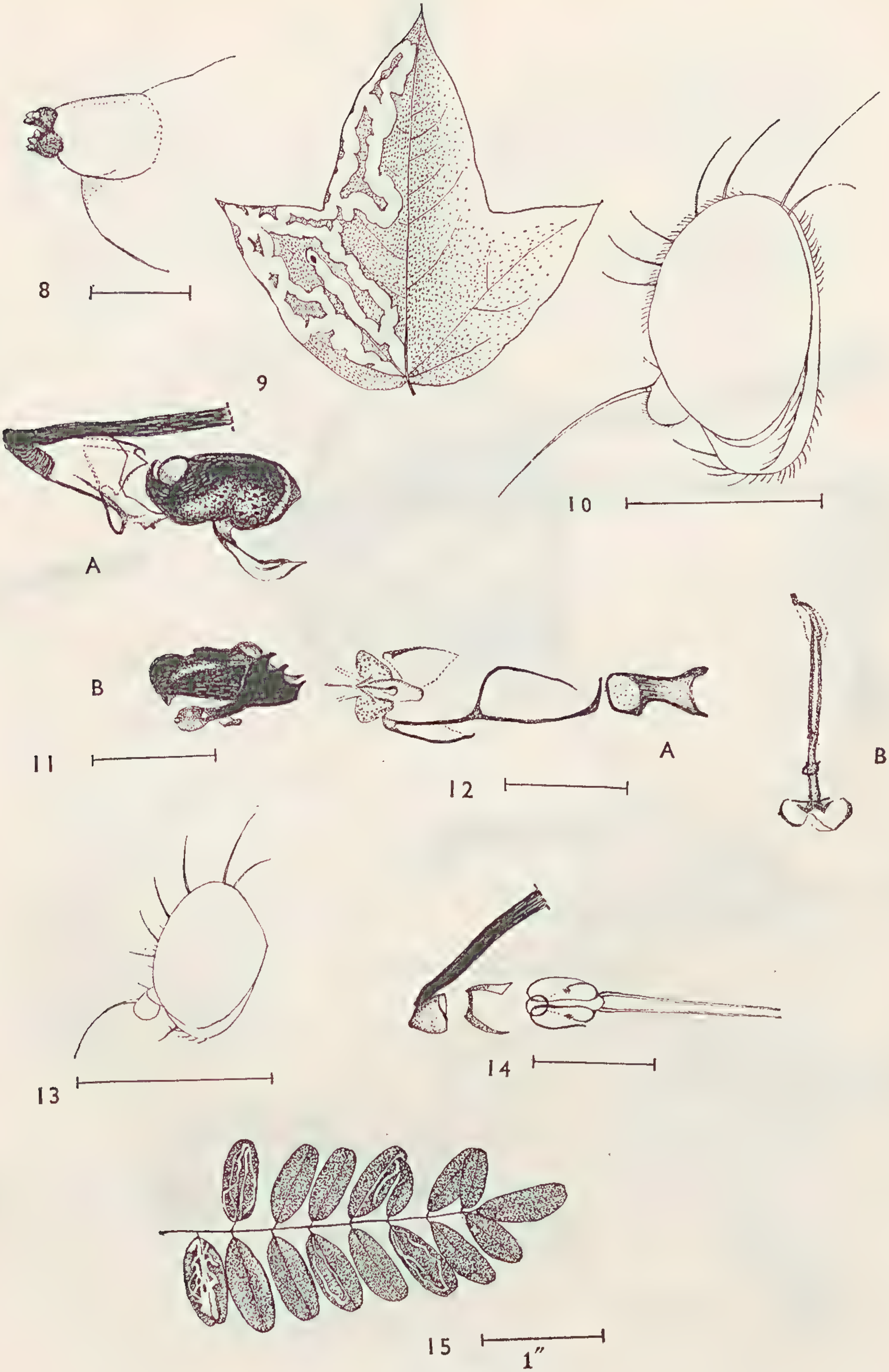
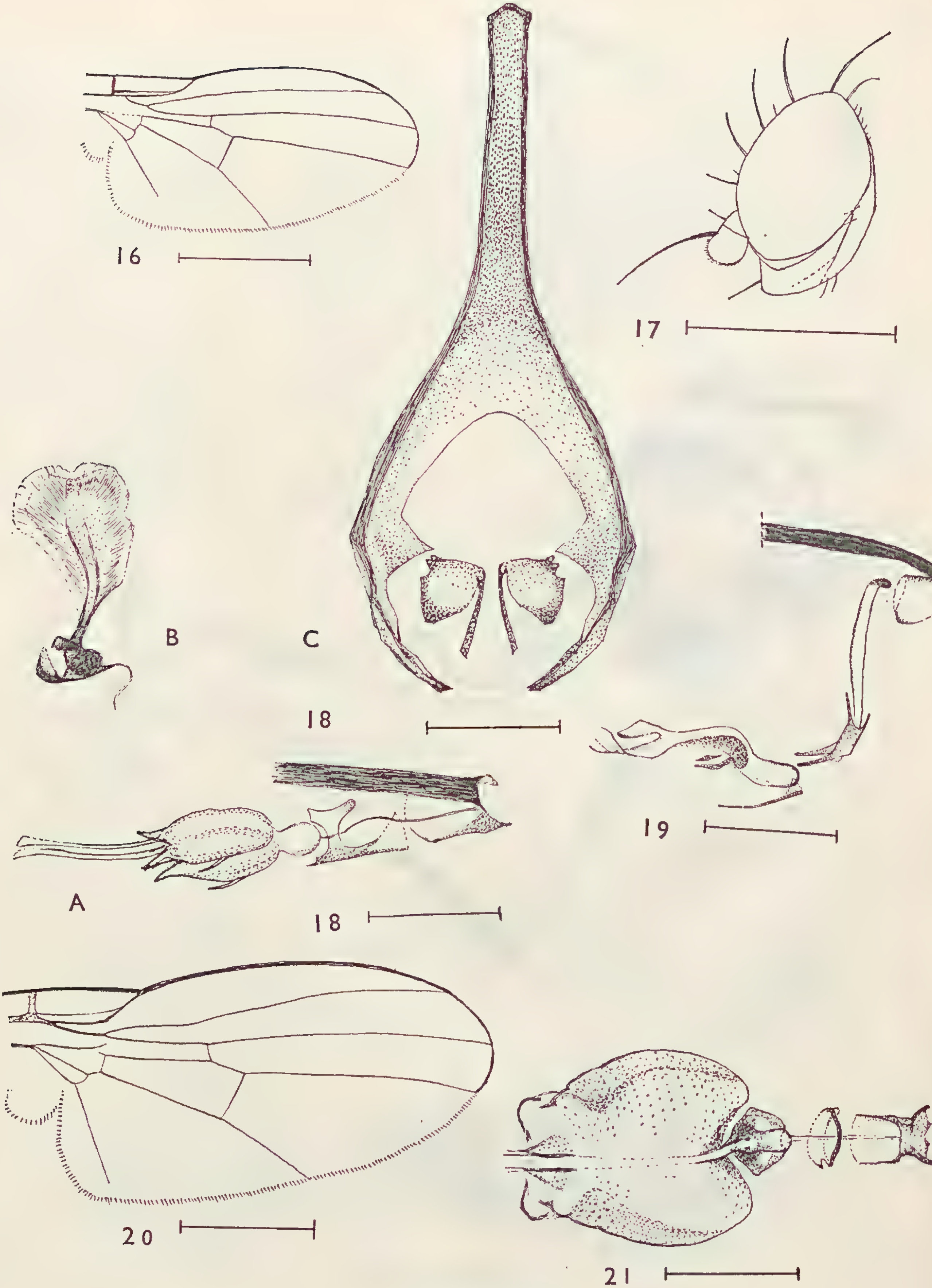
77. *Melanagromyza* sp. Posterior spiracles of puparium ex stem of *Senecio pterophorus*, Mt. Lofty, Adelaide.
78. Agromyzid sp. Leaf-mine on *Senecio* sp., Clyde Mt., N.S.W.



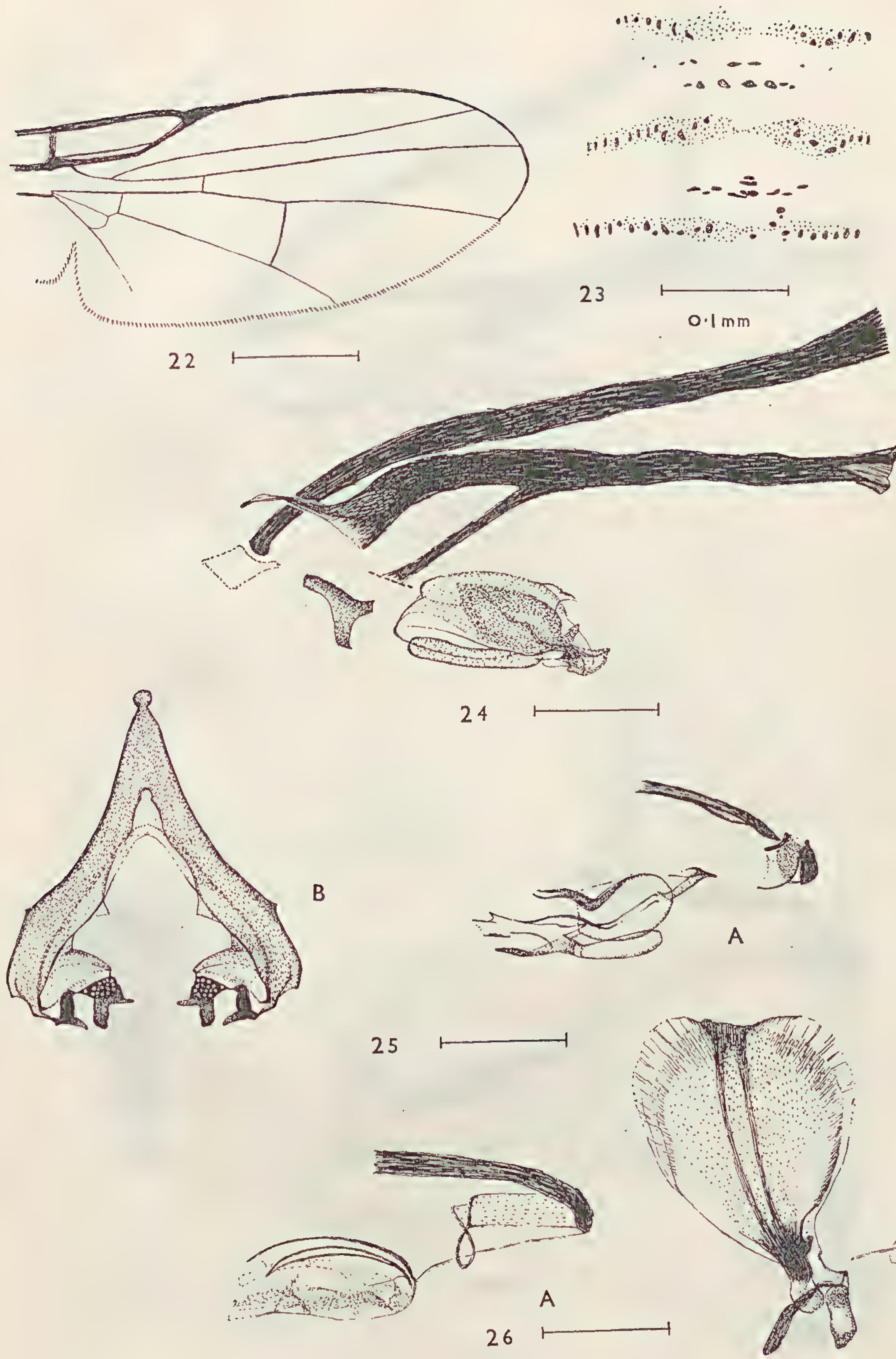
Figs. 1–7.



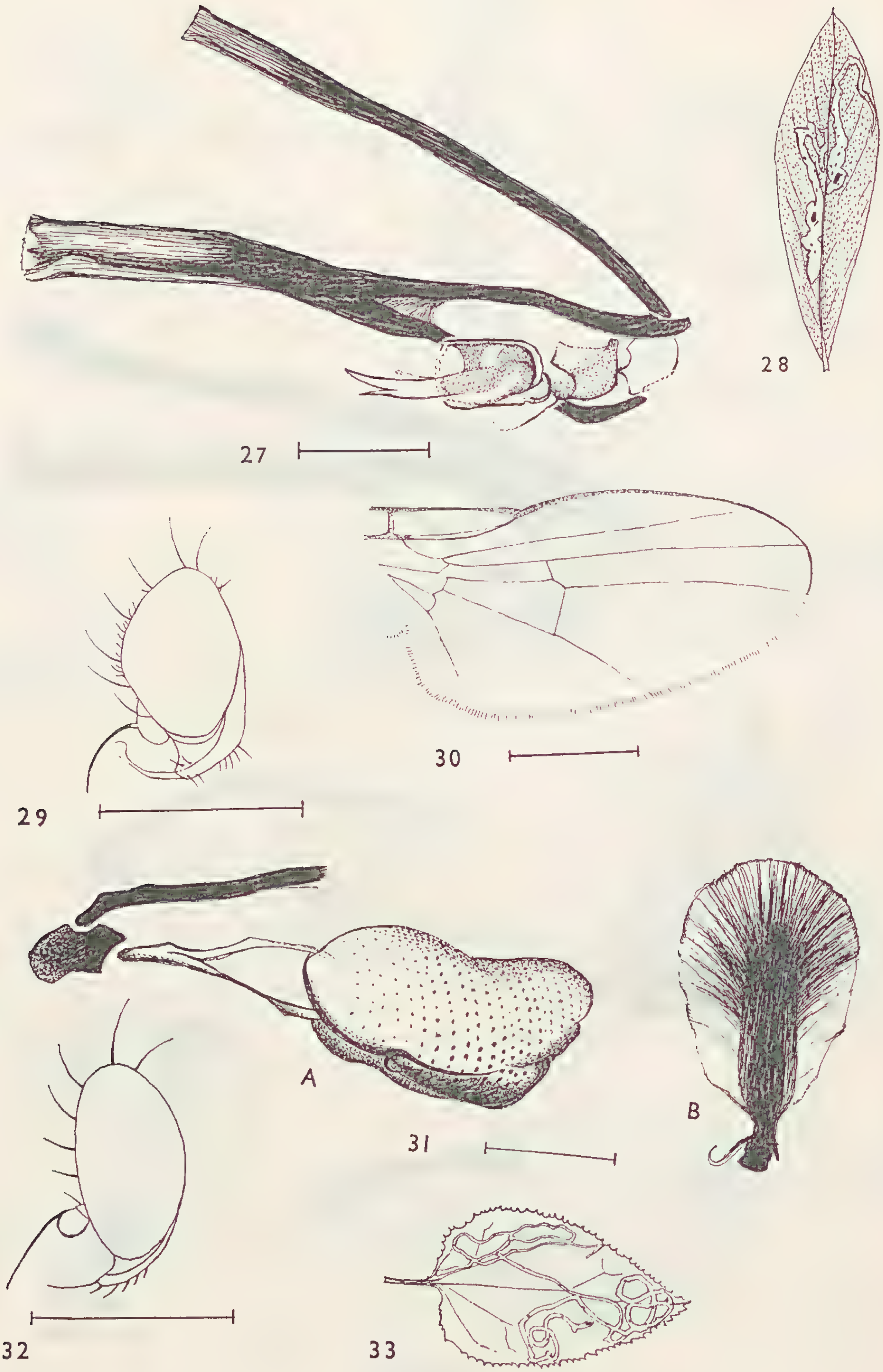
Figs. 8–15



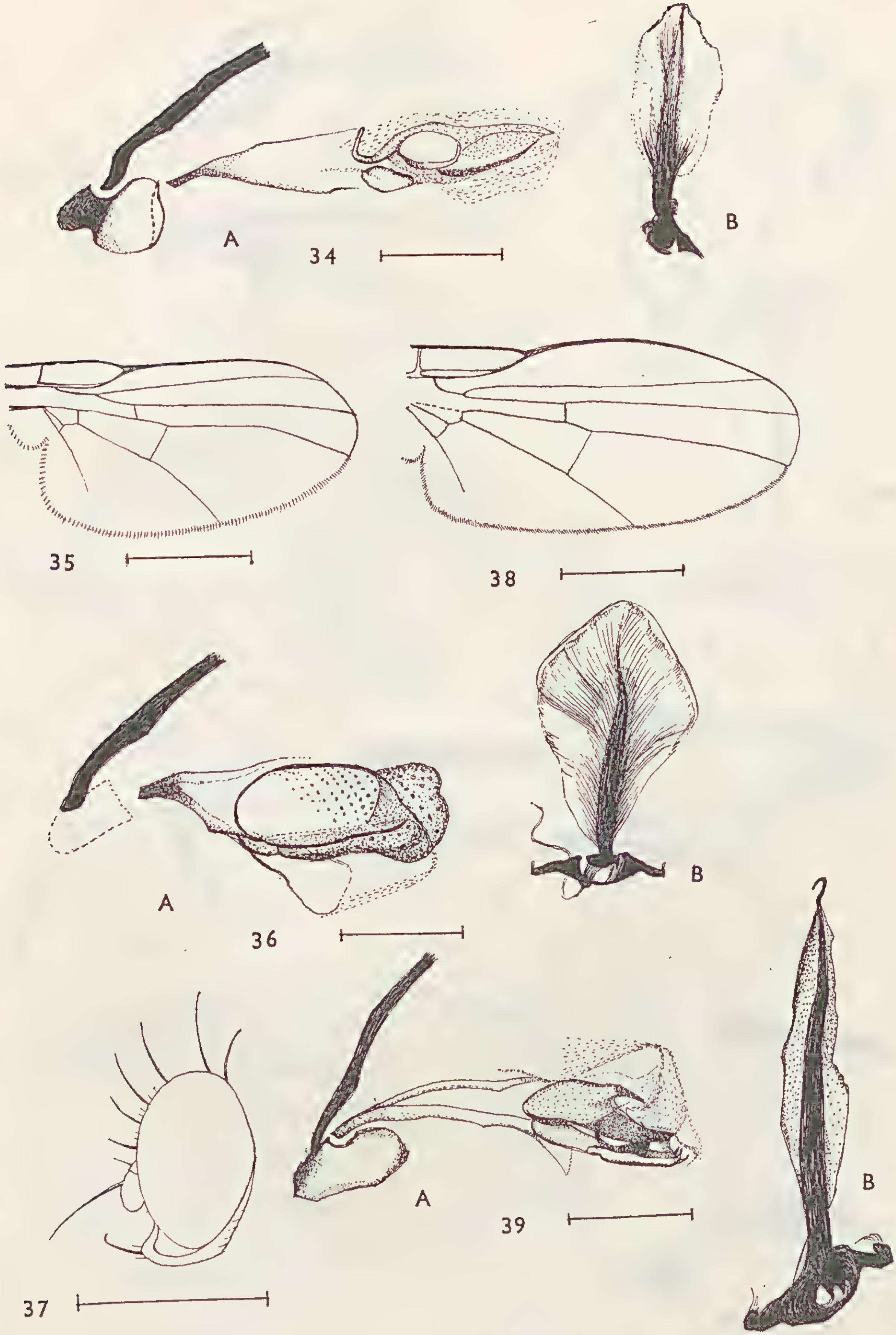
Figs. 16–21



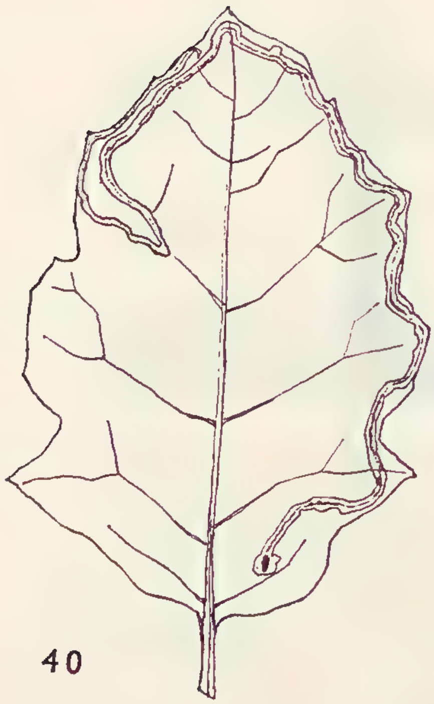
Figs. 22–26



Figs. 27–33



Figs. 34–39



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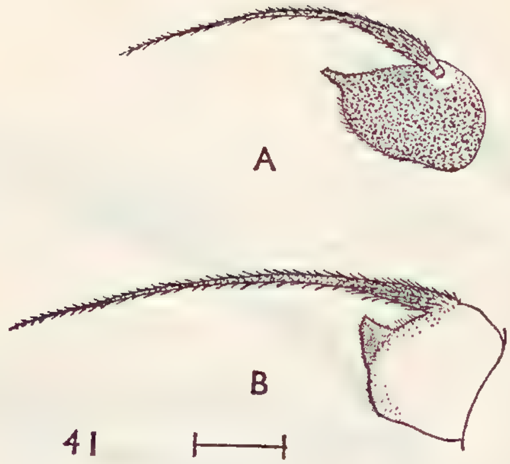

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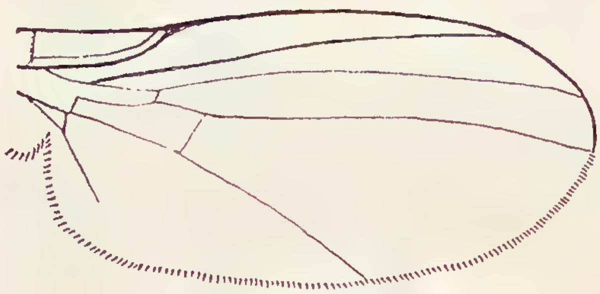

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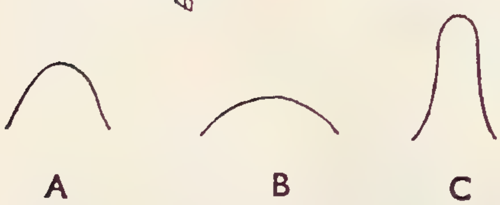

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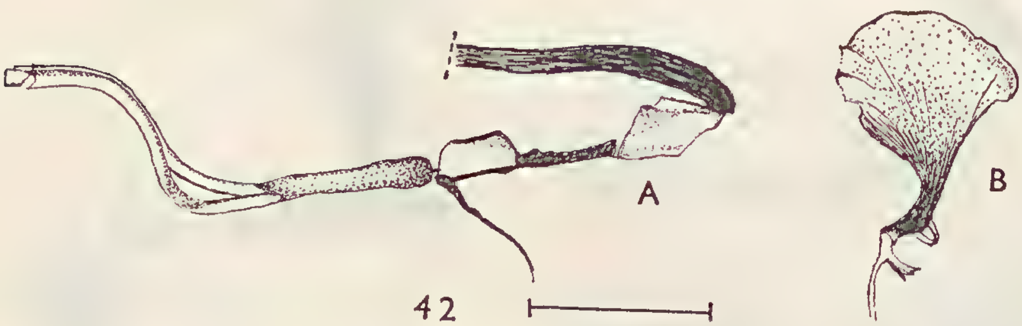

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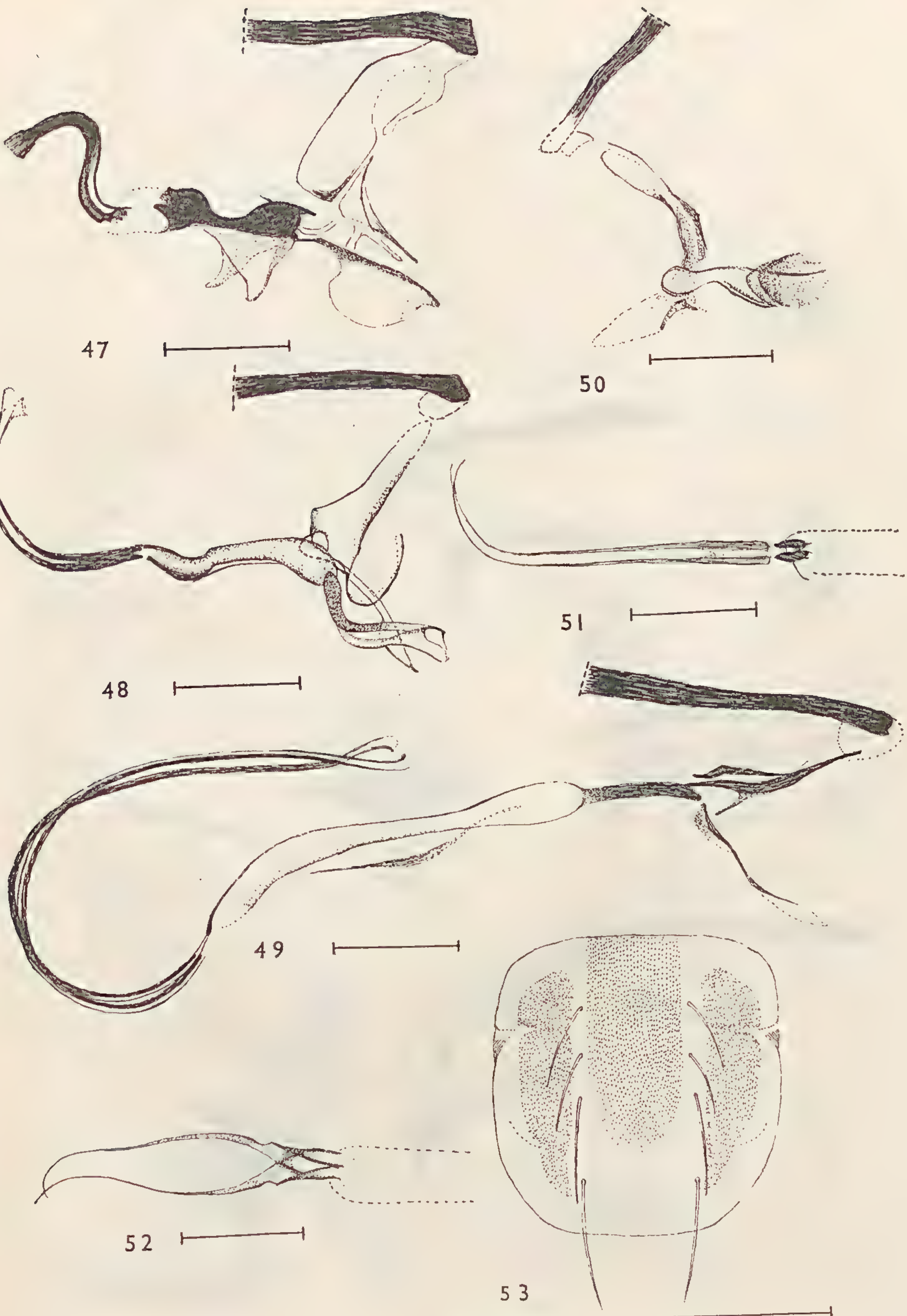

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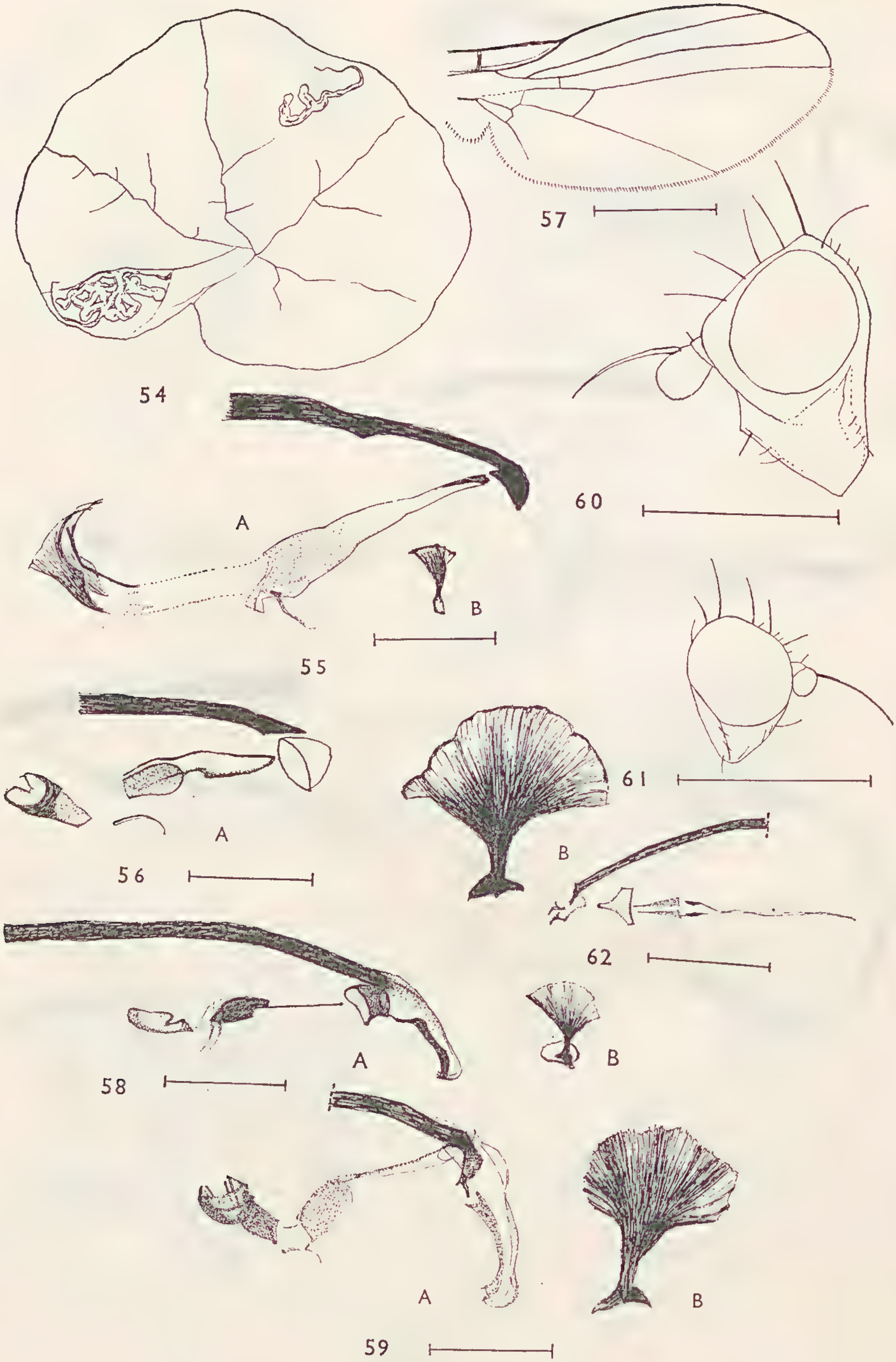

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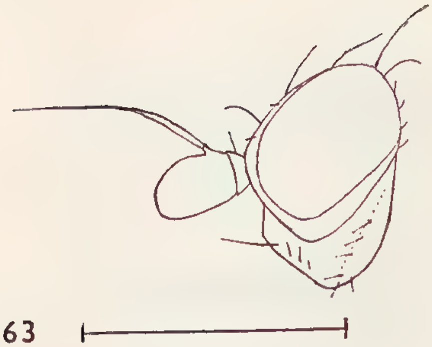

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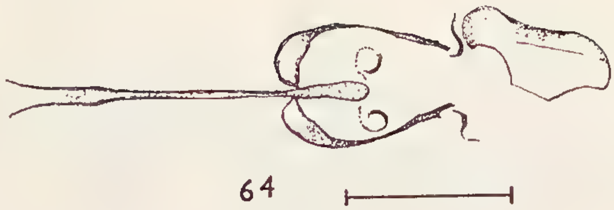

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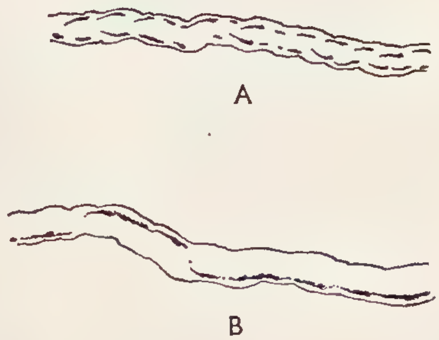

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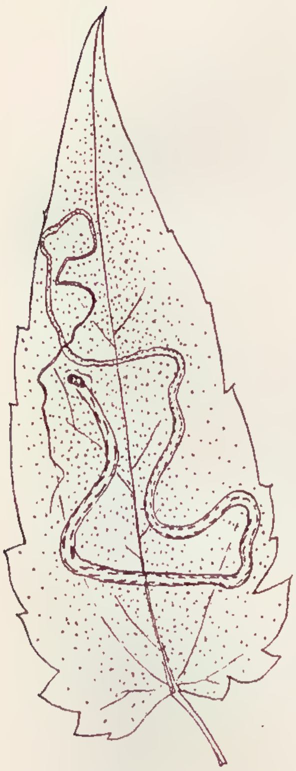

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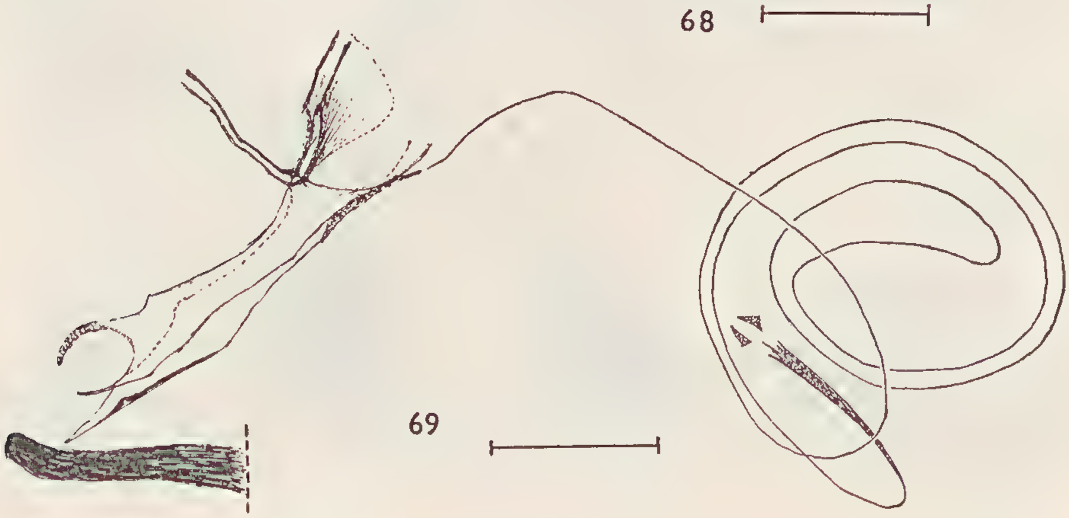

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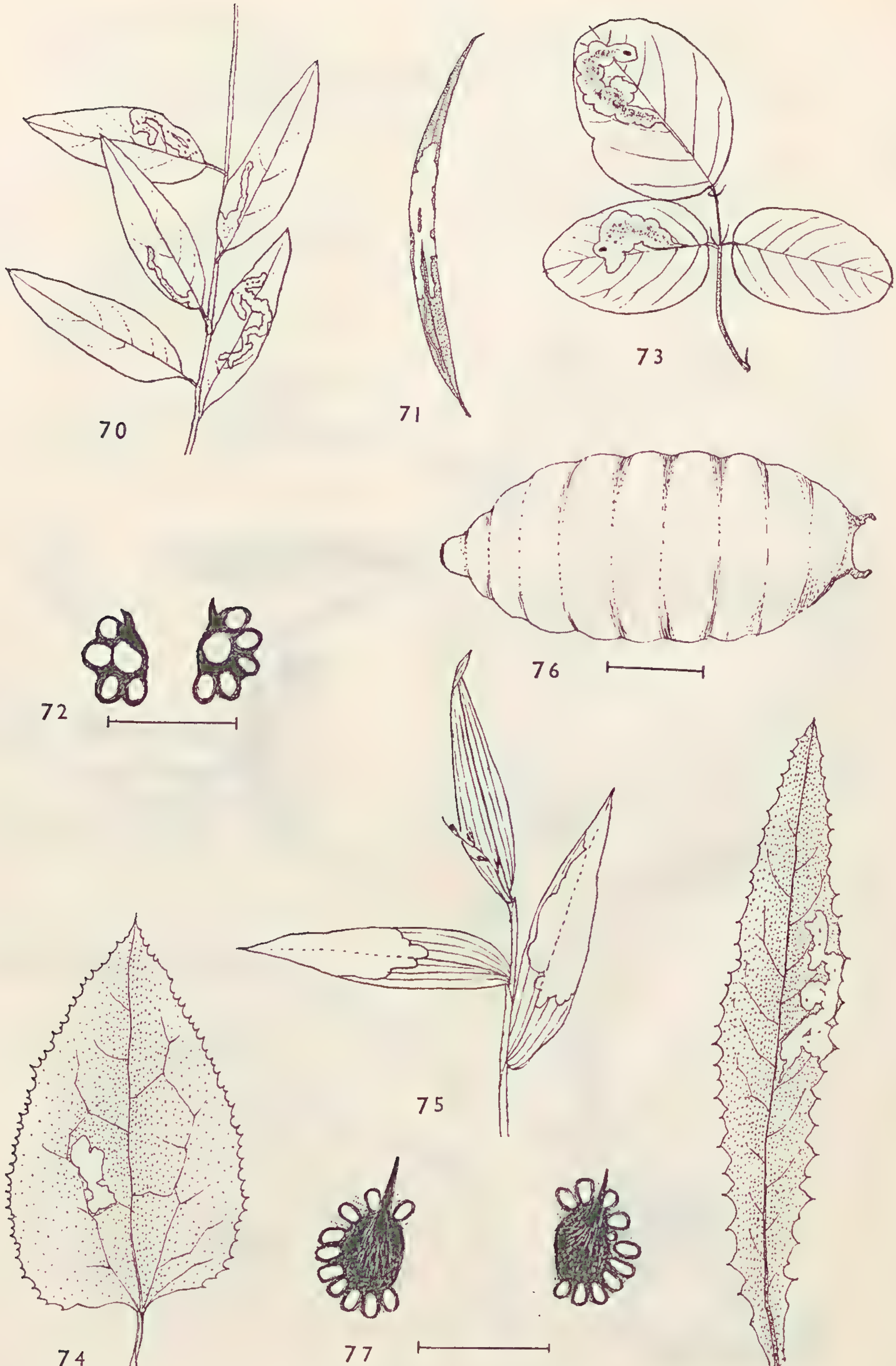

Figs. 70–78

RETETEREBELLA QUEENSLANDIA, A NEW GENUS AND SPECIES OF POLYCHAETOUS ANNELID FROM QUEENSLAND, AUSTRALIA

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(Figs 1-3)

The collection on which this description is based was received from Miss Isobel Bennett, of the University of Sydney, Australia, whom I thank for the privilege of examining these materials. Mr. Anker Petersen prepared the plate of figures. The holotype specimen is deposited in the Australian Museum, Sydney, New South Wales (Australian Museum Registered Number, W. 3755); a cotype is in the Allan Hancock Foundation, University of Southern California, Los Angeles, California.

Reteterebella, new genus

Type **R. queenslandia,** new species

Reteterebella belongs to the subfamily AMPHITRITINAE Hessle, 1917. Thoracic uncini are in simple rows in five, and in double alternating rows in 11, segments. All uncini are avicular, have a short base and a main fang surmounted by two (or few) smaller teeth. Thoracic setae are first present in the first postbranchial (- fourth) segment, together with uncini in single rows. The setae are entirely smooth along the cutting edge and narrowly limbate along the free length. The thorax consists of a smooth peristomium, three branchial segments and 16 thoracic setigerous segments. Branchiae number three pairs; each one has a basal stalk and terminates in dendritic branches. Lateral lappets are present on the first few segments, but inconspicuous. Nephridial papillae number three pairs, present on the second and third branchial, and first setigerous, segments; gonadial papillae, resembling the nephridial, occur on three successive segments, or setigerous 2 to 4. Ventral scutes are present from the third branchial, and through most thoracic, segments.

Reteterebella is allied to *Eupolymnia* Verrill (as *Polymnia* in Hessle, 1917, p. 174) from which it differs in: (1) thoracic setigerous segments number 16 instead of 17; (2) thoracic uncini are first present from the first, instead of second, setigerous segment, and (3) the first appearance of alternating rows of uncini is in the sixth, instead of eleventh, segment.

The generic name refers to the method of feeding, or casting out its tentacles as a seine, to capture micro-organisms.

Reteterebella queenslandia, new species

Plate 1, figs. 1-3

Collection.—Two specimens come from Heron Island flat, Queensland, Australia, intertidal zone, under dead coral boulders.

Length of a male specimen is 83 mm. without the tentacles, and width is 15 mm. in the middle thoracic, or widest part. A mature female is somewhat larger and has similar proportions. Preserved specimens are drab pale-yellow and have no colour except for the minute black eyespots; they encircle the peristomium as a narrow band behind the insertion of the numerous tentacles. In life the branchiae are brownish red and the body is dull white (Miss Bennett, in litt.).

The anterior end has many slender, longitudinally grooved tentacles (some are shown in fig. 1); they form a tangled mass and comprise a bulk nearly two to three times the size of the body. The latter is massive and tumid in the thorax, then tapers rapidly in the abdomen to a slender pygidial end. The thorax consists of a complete peristomial ring and three branchial, followed by 16 setigerous, segments. The abdomen includes at least 75 segments and brings the total to about 95 segments. The peristomial ring is followed by three branchial segments, each of which forms a complete ring. The first branchiae are much the longest, the second about half as large as the first, and the third considerably smaller. Each has a large, long trunk and is richly divided into many branchlets. There are no brown specks or spots on either trunk or branchiae, such as occur in some terebellids.

Lateral lappets are inconspicuous. The first branchial segment has a foliaceous process at its anterior end; this extends across the ventrum to join a similar process on the opposite side. The second branchial segment has a similar, but smaller, lobe, mainly lateral in position, and the third branchial segment lacks lappets.

Ventral scutes are first present from the third branchial segment; this one and that on the first setiger are the broadest; thereafter scutes are narrower, but extend across the ventrum to the inner bases of the uncinigerous tori.

Uncini are first present from the first setigerous segment, disposed in a single, transverse row about as long as the other thoracic tori; they occur in double, alternating rows from the sixth through sixteenth setigers. Abdominal tori are much shorter, their length about a third or fourth that of thoracic tori, and they decrease in size posteriorly.

Thoracic setae are of one kind, all long, with smooth margin and very slightly (fig. 3) or not at all limbate along their free distal part; those in the superiormost part of the fascicle are largest and those farther down are gradually smaller. Thoracic uncini are broadly avicular, and have a large basal fang surmounted by two slender teeth in a transverse row (fig. 2). Abdominal uncini are similar but slightly smaller, and may have an occasional third or fourth, much smaller distal tooth.

Nephridial papillae number three pairs, and are externally visible as a slightly pedunculate papilla below the base of the second and third branchial pairs, and on the first setigerous segment, below the notopodial fascicle. Three gonadial papillae, resembling the nephridial papillae, but without a peduncle, are visible on the second to fourth setigerous segments, slightly below the level of the nephridial papillae. In the female specimen the gonadial papillae are more diffuse and somewhat elevated. A noteworthy study of these papillae for sexual differentiation has been made by Benham (1927). The posterior end terminates in a constricted, longitudinally wrinkled ring without processes.

Reteterebella queenslandia is at present known only from Heron Island reef flat, Queensland, Australia, and is " common all over the inner, sandier parts of the flat, usually under dead coral boulders. For an area up to 2 or 3 ft. square the thin, white tentacles spread over the sand, coming out from among the dead coral. When one is touched, all contract and disappear from sight. If the boulder is turned over, one can generally find the worm and its tube which is loosely attached somewhere in the crevice on the under side of the boulder." (Isobel Bennett, in litt.)

Footnote—Reteterebella queenslandia is illustrated as Terebella, in Gillett and McNeill, " The Great Barrier Reef and Adjacent Isles ", plate 110. 1959. Coral Press, Sydney, Australia.

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EXPLANATION OF FIGURES

Fig. 1. Entire individual with only a few of the long tentacles shown, in right lateral view, x 2.

Fig. 2. Thoracic uncinus from sixth setigerous segment, in lateral view, x 7,150.

Fig. 3. Thoracic seta with a slight limbate margin, from sixth setigerous segment, x 7,150.

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